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Research, Development and Technology

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Water Reducing Admixtures in PCCP Mixes

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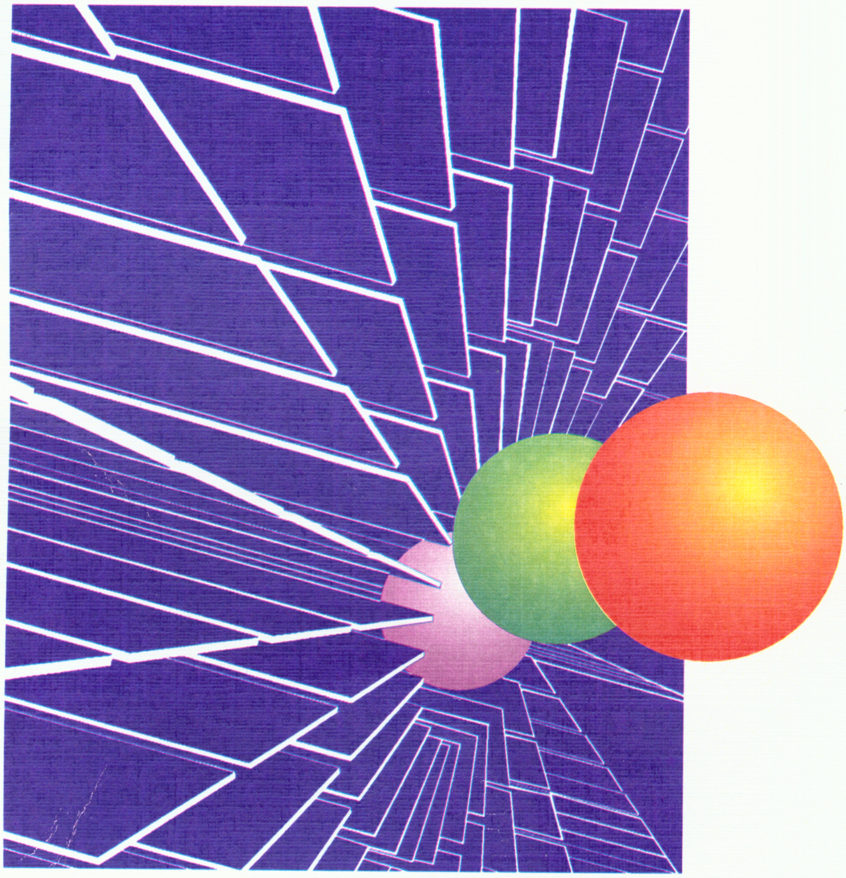

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16. Abstract
The purpose of this investigation was to determine the potential benefits and cost savings of adding a Type A water reducer and lowering the cement content in MoDOT's PCCP mixes. As a result of adding a water reducer to PCC paving mixes, it is proposed that the cement content can be decreased along with a reduction of mixing water. It is also proposed that adding a water reducer will promote complete hydration of the cement particles resulting in an improved hardened concrete product in terms of strength, durability, and performance.

This research investigation was a two-part study that included both laboratory and field results of PCCP mixes containing a Type A water reducer with cement reductions ("water reducer mixes") and standard PCCP mixes ("control mixes"). The concrete specimens fabricated in the laboratory and the field were tested to determine the following characteristics of the PCCP mixes:

7-day compressive strength	(AASHTO T22)
28-day compressive strength	(AASHTO T22)
7-day flexural strength	(AASHTO T97 or T177)
28-day flexural strength	(AASHTO T97 or T177)
freeze-thaw durability	(AASHTO T161)
air void analysis	(ASTM C457)
rapid chloride permeability	(AASHTO T277)

This report presents the findings from both the laboratory and field study by comparing concrete characteristics of PCCP mixes containing a Type A water reducer and reduced cement contents to a conventional mix.

17. Key Words
water reducer, PCCP, strength, durability, performance

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WATER REDUCING ADMIXTURES
IN PCCP MIXES

PREPARED BY
MISSOURI DEPARTMENT OF TRANSPORTATION
RESEARCH, DEVELOPMENT, AND TECHNOLOGY

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Steve Jackson, Physical Testing Supervisor, scheduled and tested all concrete specimens fabricated in this project and reported the results in a timely manner.

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EXECUTIVE SUMMARY

The purpose of this investigation was to determine the potential benefits and cost savings of adding a Type A water reducer and lowering the cement content in MoDOT's PCCP mixes. As a result of adding a water reducer to PCC paving mixes, it is proposed that the cement content can be decreased along with a reduction of mixing water. It is also proposed that adding a water reducer will promote complete hydration of the cement particles resulting in an improved hardened concrete product in terms of strength, durability, and performance. If water reducers improve the performance of concrete with less cement in the mix, then MoDOT should achieve a better product at a lower cost.

This report presents results from laboratory and field studies of PCCP mixes containing Type A water reducers and lower cement contents. The main findings of this investigation can be summarized as follows:

- PCCP mixes containing a Type A water reducer and at least a ¼-sack reduction in cement show increases in compressive and flexural strength compared to a conventional mix. Both mixes are produced at approximately the same water/cement ratios.

- The laboratory freeze/thaw results indicate no additional benefit or detriment to freeze/thaw resistance for the mixes containing water reducer and lower cement content. All laboratory mix designs achieved above a 95 freeze/thaw durability factor.

- The field freeze/thaw results indicate poor freeze/thaw performance (< 60 durability factor) by both the control and water reducer mixes. The poor durability is probably due to the quality of the aggregate, but further testing is needed to verify this. The control mix had approximately 12% higher durability compared to the water reducer mix. It appears that this is partly due to the relatively lower air contents in two of the water reducer intervals compared to the control mix.

- The water reducer does not appear to alter the air void structure of the concrete and proves to have the proper air bubble spacing factor, specific surface, and size distribution for good freeze/thaw performance.

- The PCCP mix containing the water reducer with a ¼-sack reduction in cement cost less than a standard PCCP mix. The proposed savings for the field demonstration project was approximately $0.28 per cubic yard.

Based upon laboratory and field testing results and observations, Research, Development, and Technology recommends that Type A water reducers can be used to obtain better concrete characteristics at lower costs compared to conventional PCCP mixes. Further testing of field PCCP mixes containing different brands of Type A water reducers, ¼-sack cement reductions, and different aggregate materials is needed in order to validate improved or equivalent concrete characteristics of the water reducer mixes compared to conventional field PCCP mixes.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Water reducing admixtures for concrete have been around for over 75 years, but have seldom been used in MoDOT's PCCP mix designs. MoDOT specification allows the use of water reducers, but the additional cost of the additives make it impractical to compete with the cost of a conventional mix. Also, the different additives often complicate the design and control of concrete characteristics. However, water reducers increase the quality of concrete by lowering the water/cement ratio while maintaining workability. Concrete mixes with lower water/cement ratios are known to be better mixes because of their increased strength and durability characteristics compared to mixes with higher water/cement ratios.

Other states have allowed the use of water reducers with cement reductions in their PCCP mixes, normally by specifying mix characteristic limits rather than mix design limits[1]. In MoDOT's quest for improving the condition of the state roadway system, it is necessary to explore the opportunity to increase the strength and durability of our PCC pavements at a lower cost by allowing the use of water reducers with cement reductions in PCCP mixes. This report presents the findings from both a laboratory and field study comparing PCCP mixes containing a Type A water reducer and reduced cement contents to a conventional mix.

OBJECTIVE

The objective of this investigation was to determine the potential performance benefits and cost savings of adding a Type A water reducer and reducing cement content in MoDOT's PCCP mixes. MoDOT personnel in Research, Development, and Technology (RD&T) developed PCCP mix designs containing a Type A water reducer at various dosage rates and various reductions in cement content. Concrete specimens were fabricated from the mix designs and tested in the central laboratory. RD&T also fabricated and tested concrete test specimens taken from a field PCCP mix containing a ¼-sack reduction in cement (per cubic yard) and approximately 3 oz/sack of Type A water reducer.

The concrete specimens fabricated in the laboratory and the field were tested to determine the following characteristics of the PCCP mixes:

7-day compressive strength	(AASHTO T22)
28-day compressive strength	(AASHTO T22)
7-day flexural strength	(AASHTO T97 or T177)
28-day flexural strength	(AASHTO T97 or T177)
freeze-thaw durability	(AASHTO T161)
air void analysis	(ASTM C457)
rapid chloride permeability	(AASHTO T277)

DISCUSSION OF PRESENT CONDITIONS

Presently, MoDOT allows the contractor the option to use Type A water reducing admixtures in any concrete, but maintain all cement requirements outlined in Section 501.2.2.3 of MoDOT Standard Specifications. Thus, contractors have usually elected not to use Type A water reducers until the cement content in PCCP mixes can be lowered to make them more cost competitive with conventional mixes.

The research performed in this investigation is essential to verify whether or not PCCP mixes containing a Type A water reducer and lower cement content will perform equal to or better than a conventional mix in terms of strength and durability and at a lower cost.

TECHNICAL APPROACH

This research investigation was a two-part study that included both laboratory and field results of PCCP mixes containing a Type A water reducer with cement reductions (“water reducer mixes”) and standard PCCP mixes (“control mixes”). The mixing and sampling schemes for both studies are outlined in the following sections. More information can be found in the RD&T work plan located in Appendix A of this report.

Laboratory Study

The purpose of this laboratory study was to determine concrete mix characteristics and properties when using a Type A water reducer with cement reductions. Several mix designs were developed in the laboratory containing various levels of Type A water reducer and cement. One mix design was developed to represent a control for this study. The control mix is a standard mix PCCP mix that meets all MoDOT specifications and contains no water reducing admixtures. The control mix contained 6.20 sacks/yd^3, which represents the average cement content allowed by specifications for PCCP mixes with Class A sand. Cement content for the other mixes was reduced from that of the control in 0.2 sack/yd^3 increments to 5.6 sacks/yd^3. Minimum and maximum water reducer dosages were used following the manufacturers recommendations of 3 to 5 ounces per sack of cementious material. Mixes were also performed that contained no water reducer but had a cement reduction for informational and comparison purposes. Therefore, both the cement content and dosage rate of the water reducer were the known or “fixed” variables in this study. Different combinations of these variables were used to develop 10 different mix designs outlined in Table 1.

Numerous trial batches were conducted in the development of the 10 mix designs. The trial batches were tested for slump, air content, and unit weight. The unknown variables in the mix designs include the amount of air agent and mixing water. Concrete mixing was conducted by trial-and-error using these variables until the target values of approximately a 2-inch slump and 5½ % air content were achieved for each mix design. The water/cement ratio was established at these target values.

Once the mix designs were established, the concrete mixing for fabrication of the concrete test specimens was conducted. For each of the 10 mix designs, three concrete batches were mixed to represent that mix design. The batches were mixed in random order and one set of concrete specimens per test was fabricated from each batch for a total of 30 sets. The concrete batch sheets for each mix design can be found in Appendix B, which contain the actual slump, air content, admixture amounts, w/c ratio, aggregate properties, and other batch characteristics. The concrete specimens fabricated from each batch were tested for compressive and flexural strength, freeze thaw durability, rapid chloride permeability, and air void structure following the AASHTO Specifications as listed in Table 2. The fabrication of concrete test specimens for this study was performed according to AASHTO T126, *Making and Curing Concrete Test Specimens in the Laboratory*.

The source/manufacturer and description of the materials that were used for the laboratory study are as follows:

Coarse Aggregate:	Capital Quarries, Holts Summit 1A Gradation D Limestone Cedar Valley, Ledges 1-3
Fine Aggregate:	Capital Sand #1, Jefferson City Missouri River Sand, Class A
Cement:	LaFarge Corporation Sugar Creek Plant Type 1
Air Agent:	General Resource Technology (GRT) Polychem VR Air Entraining Admixture
Water Reducer:	General Resource Technology (GRT) Polychem 400NC Type A Water Reducer

Field Study

A PCCP mix design containing a Type A water reducer and a ¼-sack cement reduction was sampled from the field. A standard mix containing no water reducer and no cement reductions was also tested for comparison purposes. The PCCP paving project was located in District 6, St. Charles County, on the Cool Springs Road/I-70 interchange. Concrete specimens were fabricated from both mixes and laboratory tested for compressive strength, flexural strength, freeze thaw durability, permeability, and air void structure following AASHTO Standard Specifications as listed in Table 3. The fabrication of concrete test specimens was conducted according to AASHTO T23, *Making and Curing Concrete Test Specimens in the Field*.

For a thorough comparison of water reducer mixes versus the control mixes, the contractor was requested to follow a certain paving sequence. The paving sequence started with a control mix, then switched to the water reducer mix, and finally returned back to the control mix, all within the same day. Sampling and fabricating of the concrete test specimens were performed at four intervals within this sequence. Each test interval within the paving sequence, as illustrated in

Figure 1, represents approximately 130 cubic yards of concrete in which sampling and fabrication of test specimens were conducted. Specimens fabricated from Control Interval 1 represented the sampling of the first control mix. The Water Reducer Intervals 1 and 2 represented the water reducer mix with a ¼ - sack reduction in cement per cubic yard. Control Interval 2 completed the sampling for the control mix. The same paving sequence of four intervals was then repeated a second day during which concrete specimens were fabricated and tested from Control Interval 3, followed by Water Reducer Intervals 3 and 4, and finally Control Interval 4. Sampling of concrete was not performed at the job site, but was conducted at the batch plant where a representative sample was obtained for each sampling interval.

Prior to the actual paving, the contractor was required to submit the proposed mix designs which included material sources and the water cement ratios, provide an outline of the proposed savings comparing the cost of the additional admixture to the savings in cement, and provide specific construction details to insure uniformity in materials, mix designs, and placement procedures.

The source/manufacturer and description of the materials used in the field study are as follows:

Coarse Aggregate:	FW/Foley Quarry Plattin Limestone Ledges 18-22
Fine Aggregate:	St. Charles Sand Company Missouri River Sand, Class A
Cement:	Holnam Cement Company Clarksville, Missouri Type 1 Cement & Class C Fly Ash (15%)
Air Agent:	General Resource Technology (GRT) Polychem VR Air Entraining Admixture
Water Reducer:	General Resource Technology (GRT) Polychem 400NC Type A Water Reducer

RESULTS AND DISCUSSION

This research investigation was a two-part study that included both laboratory and field results of PCCP mixes containing a Type A water reducer with cement reductions (“water reducer mixes”) and standard PCCP mixes (“control mixes”). The results of each study are described within the following sections.

Compressive Strength (AASHTO T22)

Laboratory Results

Compressive strength data were collected from 7 and 28-day concrete cylinders representing each laboratory mix design. Table 4 contains the average compressive strengths and mix characteristics from the three concrete batches representing each of the 10 mix designs. Individual compressive strengths from each batch are located in the laboratory data section of Appendix C. Figure 2 illustrates the effect on compressive strengths when varying the cement content and the dosage of water reducer compared to a control mix. (Note: dashed horizontal lines denote the average 7 and 28-day compressive strengths of the control mix.) The general trend follows that for given cement content, mixes containing 5 oz/sack of water reducer had greater compressive strengths than the mixes with lower dosages. This was expected, since the water reducer allows a decrease in the water/cement ratio and maintains the 2-inch target slump. Also as expected, when the cement content for a PCCP mix was decreased, the compressive strength of the concrete decreased. By lowering the cement content workability is decreased, thus, the mix needs more water (water/cement ratio increases) to maintain the 2-inch slump. One observation from the laboratory study is that the water/cement ratios of the WR mixes and control mixes were nearly the same as Table 4 indicates. Another observation of the water reducer is that it provided the concrete with greater compressive strengths compared to the control mix (6.2 sacks/yd^3), even at the lowest cement content of 5.6 sack/yd^3 as illustrated in Figure 2.

Field Results

Compressive strength data were also collected from 7 and 28-day concrete cylinders taken from both the control mix and the water reducer mix that were produced in the field. Table 5 contains the average compressive strengths and mix characteristics of each test interval that was constructed on the Cool Springs project in St. Charles County (Job #J6I1275B). Individual compressive strengths from each specimen can be found in the field results section in Appendix C. Figure 3 plots the average 7 and 28-day compressive strength of the water reducer test mixes and compares them to the control. The average 7 and 28-day compressive strengths of the control mix are denoted in the figure by the lower and upper solid lines, respectively.

Of the sampling intervals taken of the water reducer PCCP mix, two intervals exceeded the control strength by approximately 500 psi. One testing interval compared very close to that of the control strength while the final interval (WR 4) fell short to that of the control strength. It is believed that the WR4 interval had lower compressive strengths due to its higher air content (8.5%). The field evidence reveals that for every 1% increase in air content over 7%, there is approximately a 10% reduction in compressive strength. Previous studies have verified this performance trend[2,3]. As Figure 3 illustrates, the water reducer appears to increase compressive strengths despite the ¼-sack reduction in cement. The only exceptions are when the air content of the mix exceeded 7.5%. Also note from Table 5 that the average water/cement ratios for the WR mixes and the control mixes were nearly the same, 0.32 vs. 0.33, respectively. It is believed that the water reducer provided some benefit by increased compressive strengths.

Flexural Strength (AASHTO T-177 and AASHTO T-97)

Laboratory Results

AASHTO T-177 was the test method used to measure the flexural strength of the concrete test specimens. This test method uses simple beam theory with a center point load. Flexural strength data was collected on concrete beams after a 28-day curing period. Table 4 contains the average flexural strength test results and mix characteristics for each mix design. The results of the data were sporadic and inconclusive for comparison. Future testing of flexural strength warrants the use of AASHTO T-97, which tests a larger size specimen using third point loading. Third point loading provides a more thorough flexural test for the entire specimen section than single point loading. Flexural strength testing of the freeze/thaw specimens was also conducted according to AASHTO T-177, which is included in the laboratory data section of Appendix C. These results were also too inconclusive to compare.

Field Results

Due to inconclusive results of the laboratory flexural strength data of AASHTO T177, flexural strength testing on the Cool Springs project was conducted according to AASHTO T-97. The flexural strengths of the water reducer mixes appeared to follow the same trend as the field compressive strengths. Only the water reducer interval that contained the high air content fell short of the flexural strength compared to the control mix. The other three intervals met or exceeded the control mix in flexural strength. However, the increase in flexural strength was not as pronounced as the increases in compressive strengths. Table 5 lists the average of three flexural strength test results for each sampling interval and the mix characteristics. Figure 4 graphically compares 7 and 28-day flexural strengths of each water reducer mix interval with the average flexural strength of the control mix. Flexural strength data for individual specimens can be found in the field section of Appendix C.

Freeze/Thaw Durability (AASHTO T161)

Laboratory Results

Concrete beams were fabricated to test the freeze/thaw durability in accordance to AASHTO T-161. All specimens received a 35-day curing period submerged in lime-saturated water. Specimens from each mix design performed relatively the same after 300 freeze/thaw cycles. All mix designs had an average freeze/thaw durability factor between 95 – 97. Table 4 lists the average freeze/thaw durability results of each mix design. The freeze/thaw results of individual specimens from each mix can be found in the laboratory section of Appendix C. There was no indication of superior or inferior freeze/thaw performance by the addition of water reducer in any mix design. Even the PCCP mixes that had the lowest cement content and contained no water reducer performed well. MoDOT utilizes the freeze/thaw test primarily as an aggregate source test. The aggregate used in the PCCP mixes for this laboratory study had a good freeze/thaw performance history, thus any substandard results would have been due to the effects of the water reducer and/or reductions of cement to the PCCP mix.

<u>*Field Results*</u>
Concrete beams were fabricated on the Cool Springs project and tested according to AASHTO T161, *Resistance of Concrete to Rapid Freezing and Thawing*. The averages of three concrete beams for each interval were tested and are listed in the last column of Table 5. Freeze/Thaw durability for individual specimens can be found in the field section of Appendix C.
The freeze/thaw (F/T) durability of both the control mix and the water reducer mix were substandard and obtained an average F/T durability factor less than 60. The F/T testing results indicate that the coarse aggregate is questionable on its resistance to freezing and thawing cycles. MoDOT uses F/T testing as one measure of ranking coarse aggregates as to their effect on concrete F/T durability. A minimum F/T durability factory of 90 is required for the approval of new aggregate sources. Realizing that the aggregate source for this project (Plattin Limestone) has a good history of F/T durability, some localized sources of the Plattin Limestone are certainly questionable. Research, Development, and Technology (RD&T) and Materials will further investigate the quality and soundness of this Plattin Limestone source.

The air content had some effect on the strength and F/T durability of concrete. As the strength results indicate, when the air content increases, strength (compressive and flexural) decreased. However, with an increase in air content, the F/T durability also increases, as illustrated by both the control and water reducer mixes in Figure 5. On average, the control mix had a higher F/T durability factor than the water reducer mix. This is probably due to the lower air content in WR intervals 1 and 3, which also provided the higher strengths. However, WR intervals 2 and 4 had higher air contents, which provided F/T durability similar to that of the control mix. *(Note: the air contents of the concrete were taken at the batch plant. Air content of concrete generally decreases during transport, which would allow the air contents of WR intervals 2 and 4 to fall within MoDOT specifications of 5½ % +/- 1½ %.)*

Rapid Chloride Permeability (AASHTO T 277)
<u>*Laboratory Results*</u>
The rapid chloride permeability test is an electrical indication of concrete's ability to resist chloride ion penetration. This test was conducted in this lab study according to AASHTO T 277. Table 4 lists the average chloride permeability test results and mix characteristics for each mix design. The laboratory section in Appendix C contains individual specimen results. The results for any given mix design varied considerably, but the results indicate that PCCP mixes containing water reducer and decreased cement content closely compares to that of the control mixes. All the permeability tests conducted were in the range of 2000 – 4000 Coulombs, which is considered moderate permeability. This permeability range is generally common for PCCP mix designs with water/cement ratios of 0.4 to 0.5. All water/cement ratios in this study fall within this range.

<u>*Field Results*</u>
The water reducer appeared to have had a greater impact on the permeability results for the field specimens compared to the laboratory specimens. Table 5 lists the average permeability results

for both mixes tested. The average permeability for the control mix was 4226 Coulombs. The water reducer mixes appeared to decrease the average permeability by one third. These consistently lower permeabilities are most likely a direct result of the lower water/cement ratios, which were viable due to the addition of water reducer to the mixes. However, both mixes were considered to be in the same moderate permeability range of 2000-4000 Coulombs.

Air Void Analysis

Laboratory Results

Due to the complexity and time of the air void analysis test, one specimen per mix design was tested. An air void summary of the laboratory mixes is located in Table 6. The actual laboratory analysis worksheets are located in Appendix D. According to the results, the water reducer did not have a significant effect on the air void structure. The water reducer appeared to improve the air void system by slightly decreasing the spacing factor of the air bubbles and increasing their specific surface compared to the control mix. The air void structures for all mixes tested were determined adequate for good freeze/thaw resistance.

Field Results

Four specimens were fabricated for each mix at the Cool Springs project in which the air void structures were analyzed and compared. An air void summary of the field mixes is located in Table 7. The analysis worksheets are also included in Appendix D. Like the laboratory findings, the water reducer in the field study did not significantly affect the air void structure compared to the control mix. The air bubble spacing factor was identical for both the control and the water reducer mixes. The control mix has a slightly higher specific surface compared to the water reducer mix. Both the water reducer and control mixes had the proper air void structure for good freeze/thaw durability. Unfortunately, good freeze/thaw performance from either mix did not occur.

Effects to Air Entrainment Dosage

Laboratory Results

During laboratory mixing, the water reducer caused an increase in air content of the PCC mix. Therefore, the dosage of air entrainment agent was decreased in order to achieve a 5 ½ % target air content. Columns three and four in Table 4 lists the dosages of the water reducer and the air entrainment agent for both the control and water reducer mixes. WR mixes containing 3 and 5 oz./sack of water reducer decreased the dosage of air entrainment agent needed to obtain a 5 ½ % target air content. The 3 oz./sack WR mix decreased the air entrainment by approximately 40% compared to the control, while the 5 oz./sack WR mix decreased the air entrainment by approximately 68%. The savings due to the decrease in air entrainment is not considered significant, but would offset some cost of the water reducer.

Field Results

In the field study, the water reducer also appeared to increase the air content of the PCC mix. However, the reductions in air entrainment agent were not as consistent as experienced in the laboratory study. Columns three and four in Table 5 lists the dosages of the water reducer and the air entrainment agent for both the control and water reducer mixes. When comparing WR mixes 1 and 2 to Control mixes 1 and 2 (See Figure 1.), the dosage of air entrainment agent is decreased by approximately 40%. This reduction compares to the trend set by the laboratory mixing. When comparing WR mixes 3 and 4 to Control mixes 3 and 4 (See Figure 1), there was very little change in the dosages of the air entrainment agent. However, the air content of WR mix 4 was out of MoDOT specifications, thus a lower air entrainment agent may have been necessary to achieve the 5 ½ % target air content.

Effects to Water/Cement Ratio

Laboratory Results

Water reducers decrease the amount of mixing water required to maintain a target consistency in a concrete mix, thus lowering the water cement ratio. Generally, a lower water/cement ratio (w/c) will increase the strength of the concrete and enhance its durability. However, it was observed in the lab that decreasing the cement content has the opposite effect; it lowers the strength and increases the water demand for the same consistency (slump). Therefore, the laboratory mixes containing the water reducer and decreased cement content generally had the same w/c as the control mix. This can be recognized in Table 4, which lists the w/c of the laboratory mixes along with other concrete batch characteristics.

Field Results

For PCC pavements a maximum of 2 ½ - inch slump is specified in Section 501, Missouri Standard Specifications for Highway Costruction[4]. For the same target slump, the average w/c for the WR mixes were slightly lower compared to the control mixes as indicated by the batch characteristics in Table 5. The range and average of w/c of the control mix and the WR mix for the two testing dates are as follows:

Date	w/c Control Mix	w/c WR Mix
07/27/00	.34-.35 (Avg. .345)	.33-.34 (Avg. .334)
08/10/00	.30-.33 (Avg. .310)	.29 -.32 (Avg. .300)

The WR mix had approximately 3% water reduction compared to the control mix for both dates. A minimum of a 5% water reduction is a general requirement of AASHTO M 154. Typical Type A water reducers reduce the water content by approximately 5% to10%[3]. Like the laboratory results indicated, it is believed that the ¼-sack cement reduction in the WR mix caused an increase in the water demand that somewhat counteracts the effect of the water reducer when achieving a the same target slump. Therefore, there may not be a minimum 5% water reduction in a mix with water reducer when there is a decrease in the cement content. Also, the average field slumps of the water reducer mix were lower than the slumps of the control mix, which corresponds with the slightly lower w/c of the WR mix. Consequently, the WR mix in this project could have had less than a 3% water reduction to achieve the same slump.

CONCLUSIONS

This paper presents a performance evaluation of PCCP mixes containing a Type A water reducing admixture and a decrease in cement content. The evaluation is based upon both laboratory and field findings. The main findings of this study are summarized as follows:

1. Despite the cement reduction in the mix, compressive strengths of the concrete tended to increase with the added water reducer, except at higher air contents.

2. Laboratory flexural strengths using AASHTO T-177 (single point loading) were inconclusive. Field flexural strengths using AASHTO T-97 (third point loading) were more consistent and generally followed the same trend as the compressive strengths. Flexural strengths for water reducer mixes were greater than or equal to the control, except at higher air contents.

3. The lab and field PCCP mixes with water reducer and decreased cement content relatively had the same water/cement ratio as the standard (control) PCCP mixes. The water/cement ratios of the WR mixes in the field were slightly lower compared to the control mixes.

4. Laboratory freeze/thaw results concluded that no additional benefit or detrimental effect in freeze/thaw durability was found for the mixes containing water reducer and a decrease in cement. All specimens from each mix tested above a 95 freeze/thaw durability factor.

   The average freeze/thaw durability of field specimens from both the control and water reducer mixes was substandard and tested below a 60 freeze/thaw durability factor. On average, the durability factor for the control mix was higher compared to the durability factor of the water reducer mix. This difference may be the result of the relatively lower air content of two intervals of the water reducer mix. The water reducer mixes containing relatively lower air proved to have an adequate air structure to resist freezing and thawing cycles. The overall substandard freeze/thaw durability is thought to be an aggregate quality problem in which further investigation is required.

5. Rapid chloride permeability tests on field specimens indicated an improvement in chloride resistance for the PCCP mixes containing water reducer and reduced cement content. Laboratory chloride permeability tests compared closely for both the control and water reducer mixes. All mixes in both studies had chloride resistance results in the moderate permeability range (2000-4000 Coulombs).

6. The air void structure of the concrete remained relatively constant for all mixes in the laboratory and field studies. The air bubble spacing factor, specific surface, and size distribution were relatively similar for all mixes. Air void structures for both control and water reducer mixes contained proper air structure for good freeze/thaw performance. However, poor freeze/thaw performance was obtained in the field as abovementioned.

7. The water reducer increased the air content of the PCC mix which resulted in decreased dosages of air entrainment agent required to obtain a 5 ½ % target air content. The laboratory study indicated that the air entrainment dosage decreased by approximately 65% while the air entrainment decrease in the field study was 40% or less. The savings of decreasing the air entrainment is minimal and not significant.

8. The PCCP mix containing the water reducer with a ¼-sack reduction (per cubic yard) in cement cost less than a standard PCCP mix. The proposed savings on the Cool Springs project was approximately $0.28 per cubic yard.

RECOMMENDATIONS

Based upon laboratory and field testing results and observations; Research, Development, and Technology recommends the following:

1. PCCP mixes with a Type A water reducer and ¼-sack cement reduction can be used to obtain equivalent concrete characteristics at lower costs compared to conventional PCCP mixes.

2. The minimum dosage rate of a Type A water reducer should be established by the dosage rate submitted for the initial admixture approval and within the ranges recommended by the manufacturer.

3. Further testing of field PCCP mixes containing different brands of Type A water reducers, ¼-sack cement reductions, and different aggregate materials is needed in order validate improved or equivalent concrete characteristics compared to conventional field PCCP mixes.

4. Due to the poor freeze/thaw performance determined by the field study, the aggregate source (Plattin Limestone ledges 18-22) should be re-evaluated by conducting a thorough study to determine if the aggregate meets MoDOT specifications as an acceptable aggregate source.

BIBLEOGRAPHY

1. Illinois Department of Transportation (IDOT), *IDOT Standard Specifications*, Article 1020.05, p. 837.

2. Hover, K.C., *Air Content and Unit Weight of Hardened Concrete,* Significance of Tests and Properties of Concrete and Concrete-Making Materials, ASTM STP 169C, p. 297.

3. Portland Cement Association, *Design and Control of Concrete Mixtures*, Thirteenth Edition, Skokie, Illinois, 1994, p. 65 and 66.

4. 1999 Missouri Standard Specifications for Highway Construction, Section 1054.3. (References AASHTO M194)

Mix Design	Cement Content (sack/yd^3)	Water Reducer (oz./sack)	Number of Batches
Control	***6.2***	***0***	***3***
2	6.0	0	3
3		3	3
4		5	3
5	5.8	0	3
6		3	3
7		5	3
8	5.6	0	3
9		3	3
10		5	3

Table 1- Laboratory Mix Variables

Specimens/Batch	Test Description	AASHTO Method
1	7 Day Compressive Strength	AASHTO T22
1	28 Day Compressive Strength	AASHTO T22
1	28 Day Flexural Strength	AASHTO T177
1	Freeze/Thaw Durability and Flexural Strength after 300 Freeze/Thaw Cycles	AASHTO T161/ AASHTO T177
1	Air Void Analysis	ASTM C457-90
1	Chloride Permeability	AASHTO T277

Table 2 – Laboratory Sampling and Testing List for Each Batch

Sampling List for Each Interval		
No. of Specimens	**Test Name**	**AASHTO Method**
3	7-Day Compressive Strength	AASHTO T22
3	28-Day Compressive Strength	AASHTO T22
3	7-Day Flexural Strength	AASHTO T97
3	28-Day Flexural Strength	AASHTO T97
3	Freeze/Thaw Durability and Flexural Strength after 300 Freeze/Thaw Cycles	AASHTO T161/ AASHTO T177
1	Chloride Permeability	AASHTO T277
1	Air Void Analysis	ASTM C457-90

Table 3 – Field Sampling and Testing List for Each Interval

AVERAGE CONCRETE CHARACTERISTICS							AVERAGE COMPRESSIVE AND FLEXURAL STRENGTHS			AVERAGE PERMEABILITY & DURABILITY	
Mix No.	Avg. Cement (sacks/yd^3)	Avg. Water Red. (oz./sack)	Avg. Air Agent (oz/sack)	Avg. W/C Ratio	Avg. Slump (in)	Avg. Air (%)	Avg. 7-Day Compressive Strength (psi)	Avg. 28-Day Compressive Strength (psi)	Avg. 28-Day Flexural Strength (psi)	Avg. Chloride Permeability (Coulombs)	Avg. F/T Durability Factor
Control	***6.2***	***0***	***.387***	***.410***	***2.25***	***5.4***	***4193***	***5697***	***911***	***3042***	***95.7***
2	6.0	0	.400	.415	1.92	5.4	4247	5870	933	4133	95.5
3	6.0	3	.237	.403	2.00	5.7	4720	6230	915	2656	95.5
4	6.0	5	.125	.405	2.08	6.2	4823	6417	876	2944	95.4
5	5.8	0	.387	.430	2.08	5.6	4107	5640	911	3429	95.3
6	5.8	3	.250	.418	2.17	5.9	4410	5990	904	3611	95.4
7	5.8	5	.125	.408	2.17	6.0	4540	6013	934	2962	95.3
8	5.6	0	.377	.442	2.00	5.8	3943	5520	882	2716	95.5
9	5.6	3	.193	.430	2.17	5.7	4247	5877	897	2796	96.9
10	5.6	5	.125	.413	1.83	6.0	4407	6010	905	2842	96.1

TABLE 4 – Laboratory Mix Characteristics and Average Testing Results

AVERAGE CONCRETE CHARACTERISTICS							AVERAGE COMPRESSIVE AND FLEXURAL STRENGTHS				AVERAGE PERMEABILITY & DURABILITY	
Interval No.	Avg. Cement / Fly Ash (lb/yd^3)	Avg. Water Red. (oz./sack)	Avg. Air Agent (oz/yd^3)	Avg. W/C Ratio	Avg. Slump (in)	Avg. Air (%)	Avg. 7-Day Compressive Strength (psi)	Avg. 28-Day Compressive Strength (psi)	Avg. 7-Day Flexural Strength (psi)	Avg 28-day Flexural Strength (psi)	Avg. Chloride Permeability (Coulombs)	Average F/T Durability Factor
Control 1	572	0	9.8	.34-.35	2.00	6.3	4140	5095	627	669	3533	50
Control 2	572	0	9.8	.34-.35	2.00	6.3	4443	5406	663	676	3943	54
Control 3	572	0	10.6	.31-.33	3.00	6.9	4190	5155	631	648	4859	57
Control 4	572	0	10.0	.30-.31	2.00	6.3	4267	5159	602	677	4650	58
AVG	**572**	**0**	**10.1**	**.33**	**2.25**	**6.5**	**4260**	**5204**	**631**	**668**	**4246**	**55**
WR 1	546	3.5	5.5-6.0	.33-.34	0.75	5.8	4793	5869	681	694	2658	35
WR 2	546	3.5	5.5-6.0	.33-.34	1.50	7.5	4193	5299	627	663	2825	54
WR 3	546	3.5	9.6-10.6	.29-.32	1.25	6.0	4690	5532	629	680	2474	47
WR 4	546	3.5	9.6-10.6	.29-.32	2.25	8.5	3747	4612	538	600	2768	57
AVG	**546**	**3.5**	**8.0**	**.32**	**1.83**	**7.0**	**4356**	**5328**	**619**	**659**	**2681**	**48**

TABLE 5 – Field Mix Characteristics and Average Testing Results

Laboratory Air Void Summary						
Name	**Fresh %AIR**	**Hardened % AIR**	**Average Air Void (in)**	**Voids Per Inch**	**Spacing Factor (in)**	**Specific Surface (in2/in3)**
Mix 1 (Control)	**5.4**	**4.8**	**0.00495**	**9.73**	**0.00820**	**807.56**
No Water Reducer						
Mix 2	5.4	5.2	0.00467	11.08	0.00740	855.67
Mix 5	5.6	4.4	0.00466	9.55	0.00803	858.39
Mix 8	5.8	4.4	0.00454	9.73	0.00772	881.63
With Water Reducer						
Mix 3	5.7	4.8	0.00430	11.21	0.00728	931.11
Mix 4	6.2	4.9	0.00434	11.37	0.00694	921.03
Mix 6	5.9	4.7	0.00434	10.87	0.00738	920.82
Mix 7	6.0	5.1	0.00420	12.22	0.00684	952.87
Mix 9	5.7	4.6	0.00490	9.37	0.00811	816.65
Mix 10	6.0	4.4	0.00394	11.04	0.00694	1014.54

Table 6 - Laboratory Air Void Summary

Field Air Void Summary						
NAME	**Fresh %AIR**	**Hardened % AIR**	**Average Air Void (in)**	**Voids Per Inch**	**Spacing Factor (in)**	**Specific Surface (in2/in3)**
Control 1	6.3	4.8	0.00347	13.90	0.00559	1151.25
Control 2	6.9	4.5	0.00325	14.01	0.00549	1231.63
Control 3	6.3	5.3	0.00401	13.29	0.00623	997.91
Control 4	6.3	6.5	0.00489	13.28	0.00718	817.38
Average	**6.5**	**5.3**	**0.00391**	**13.62**	**0.00612**	**1049.54**
WR 1	5.8	5.8	0.00417	13.99	0.00611	959.80
WR 2	6.0	6.7	0.00420	16.03	0.00559	953.48
WR 3	7.5	6.4	0.00438	14.57	0.00622	913.14
WR 4	8.5	7.6	0.00381	19.96	0.00497	1049.63
Average	**7.0**	**6.6**	**0.00414**	**16.14**	**0.00572**	**969.01**

Table 7 - Field Air Void Summary

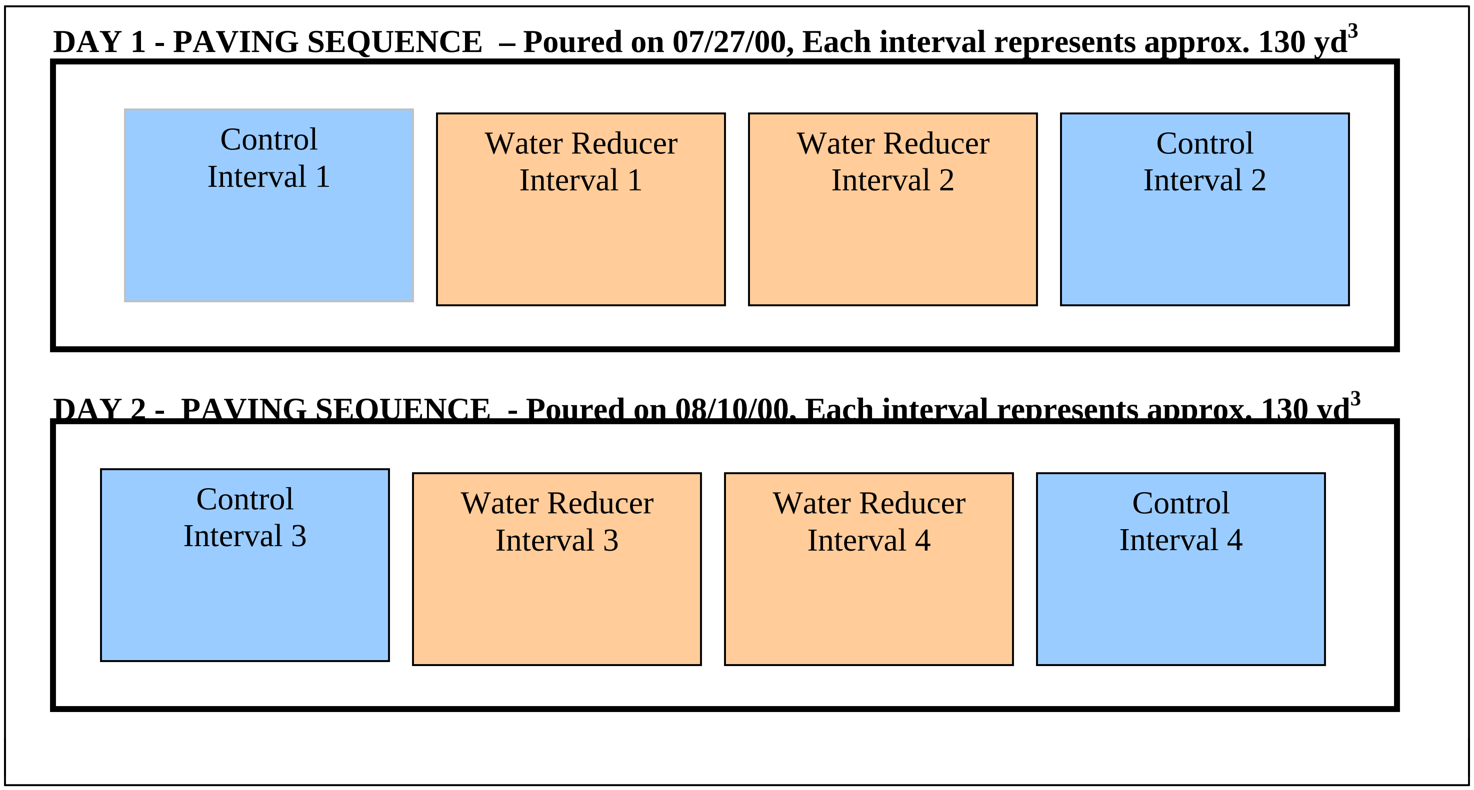


Figure 1 – Field Paving Sequence and Sampling Interval

APPENDIX A

Research, Development, and Technology Work Plan

RESEARCH WORK PLAN

Date: **01/30/00**

Project Number: **RI00-001**

Water Reducing Admixtures in PCCP Mixes

Research Agency: Missouri Department of Transportation, Research, Development, and Technology Division

Principal Investigator: Jason Blomberg, Intermediate R&D Assistant

Objective:

The objective of this investigation is to determine the potential benefits and cost savings of adding a Type A water reducer and reducing the cement content in MoDOT's PCCP mixes.

Background and Significance of Work:

As a result of adding water-reducing admixtures to PCCP mixes, it is proposed that the cement content can be reduced along with a reduction in water added. It is also proposed that adding a water reducer will promote complete hydration of the cement particles resulting in an improved hardened concrete product in terms of strength, durability, and performance. If water reducing agents improve the performance of concrete with less cement content in the mix, then MoDOT should achieve a better product at a lower cost.

Action Plan

Laboratory Testing

Concrete mix designs containing a Type A water reducer and having various reductions in cement content will be developed in the laboratory. Concrete specimens fabricated from each mix will be tested for comparison purposes. A mix design containing a standard amount of cement and no water reducer will also be developed. Specimens fabricated from this mix will be used as a control for this investigation. Specimens will be tested for compressive strength, flexural strength, freeze thaw durability, permeability, and air void structure.

Field Testing

A PCCP mix design containing a Type A water reducer and a ¼ sack cement reduction will be tested in the field. A standard mix containing no water reducer and no cement reductions will also be tested for comparison purposes. The proposed project is located at the Cool Springs Interchange on Route I-70 in St. Charles County, Missouri, Job #

J6I1275B. Concrete specimens will be fabricated from both mixes and tested for compressive strength, flexural strength, freeze thaw durability, permeability, and air void structure.

A final report will detail the conclusions and recommendations based on the results of both laboratory and field testing of the PCCP mixes.

Literature Search

Information regarding water-reducing admixtures will be obtained from concrete mix design manuals and other resources. Neighboring states, such as Iowa and Illinois, are using water reducers with significant cement reductions in their PCCP mixes. Information on their mixes may be acquired to give MoDOT some insight on mix control.

Method of Implementation

If the water reducer and reduction of cement lead to better performance of PCCP at a lower cost compared to MoDOT's standard PCCP mixes, then implementation procedures for the new concrete mix will be proposed as a cost effective alternative in concrete pavements. Implementation strategies will be identified pending results as documented in this study's final report.

Anticipated Benefits

The water-reducing admixture is intended to allow a reduction of cement content in the PCC mix and improve the overall performance of the concrete. The benefit that MoDOT should anticipate is better performance of PCCP mixes at a lower cost.

Research Period

A final report presenting the results of this investigation is intended to be complete by January 2001.

Funding

The Research Development and Technology Unit will use SPR funds for the evaluation and reporting performed for the research investigation.

Supporting Data

This research investigation is a two-part study that includes both laboratory and field results of PCCP mixes containing a Type A water reducer and a reduction in cement. The following sections describe the procedures for each study.

Laboratory Study Procedure:

Jan – Feb, 2000: Trial Batching

The MoDOT standard specifications require cement content to be in the range of 6.00 to 6.40 sacks/yd^3 for PCCP mixes using Class A natural sand. Based on this criterion, a control mixes will be developed to represent a standard mix. A standard mix is considered to be a concrete mix design that meets all MoDOT specification and contains no water reducing admixtures. The control mix will contain a 6.20 sacks/yd^3, which represents the average cement content allowed by specification.

A number of mix designs will be developed in the laboratory utilizing a Type A water reducing admixture and have a reduced cement content. Mix 1 will represent a standard mix and will be used as the control in this investigation. Table 1 shows the cement content and the dosage rate of water reducer of each mix.

Mix Design	Cement Content (sack/yd^3)	Water Reducer (oz./sack)	Number of Batches
Control	***6.2***	***0***	***3***
2		0	3
3	6.0	3	3
4		5	3
5		0	3
6	5.8	3	3
7		5	3
8		0	3
9	5.6	3	3
10		5	3

Table 1- Laboratory Mixes

Laboratory mixing will include numerous trial batches that will be tested only for slump and air. The unknown variables in the mix designs include water reducer, air agent, and water. Concrete mixing will be conducted by trial-and-error using these variables until the target values of a 2-inch slump and 5-½ % air content is achieved for each cement content. The mix designs for the test group will be developed with the lowest water/cement ratio to produce the target slump.

The source/manufacturer and description of the materials that will be used for the laboratory study are as follows:

Coarse Aggregate: Capital Quarries, Holts Summit 1A
Gradation D Limestone
Cedar Valley, Ledges 1-3

Fine Aggregate: Capital Sand #1, Jefferson City
Missouri River Sand, Class A

Cement: LaFarge Corporation
Sugar Creek Plant
Type 1 Cement

Air Agent: General Resource Technology (GRT)
Polychem VR
Air Entraining Admixture

Water Reducer: General Resource Technology (GRT)
Polychem 400NC
Type A Water Reducer

Feb. – Apr., 2000: Fabricating Specimens in the Laboratory
Laboratory Specimens
Once the mix designs are developed, the concrete mixing for fabrication of the test specimens will begin. Three separate concrete batches will represent one mix design as described in Table 1. A total of 30 batches will be mixed in a random order to produce the specimens needed for testing. Table 2 describes the samples fabricated from each batch.

No. of Specimens/Batch	Test Description	AASHTO Method
1	7 Day Compressive Strength	AASHTO T22
1	28 Day Compressive Strength	AASHTO T22
1	28 Day Flexural Strength	AASHTO T177
1	Freeze/Thaw Durability and Flexural Strength after 300 Freeze/Thaw Cycles	AASHTO T161/ AASHTO T177
1	Air Void Analysis	ASTM C457-90
1	Chloride Permeability	AASHTO T277

Table 2: Laboratory Sampling

Field Study Procedure:

July – August – Sampling Field Specimens
Field Specimens

On the Cool Springs project, field specimens will be fabricated from the concrete mix containing water reducer and the standard concrete mix without water reducer. Table 3 is a sampling plan for field sampling and testing.

For a good statistical comparison of PCCP mixes containing a Type A water reducer versus a conventional mix, the contractor will be requested to follow a certain paving sequence. The paving sequence will start with a conventional mix, then switch to a mix with the water reducer, and finally return back to the conventional mix, all within the same day. Sampling and fabricating of the concrete test specimens will be performed at four intervals during this sequence. Table 3 lists the concrete specimens that are to be sampled from each interval.

Figure 1 illustrates the interval layout for the Cool Springs project. Each interval will be approximately 250 ft. in length. Specimens fabricated from interval 1 represent the control mix. Intervals 2 and 3 represent the PCCP mix containing the Type A water reducer and ¼-sack reduction in cement. Interval 4 completes the sampling for the control mix. The same paving sequence of four intervals, as described above, will be repeated on another day during which the same concrete sampling will occur.

Sampling List for Each Interval		
No. of Specimens	**Test Name**	**AASHTO Method**
3	7-Day Compressive Strength	AASHTO T22
3	28-Day Compressive Strength	AASHTO T22
3	7-Day Flexural Strength	AASHTO T97
3	28-Day Flexural Strength	AASHTO T97
3	Freeze/Thaw Durability and Flexural Strength after 300 Freeze/Thaw Cycles	AASHTO T161/ AASHTO T177
1	Chloride Permeability	AASHTO T277
1	Air Void Analysis	ASTM C457-90

Table 3 – Sampling List for Each Interval

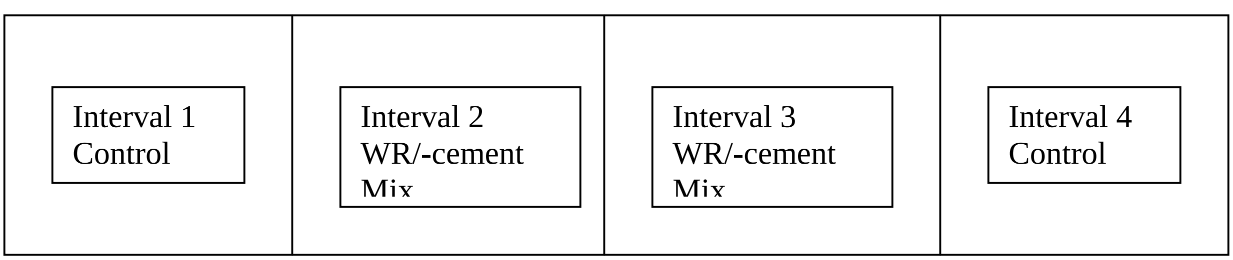


Figure 1 – Paving Sequence

Field and Laboratory Testing

September - November, 2000: Curing and Testing of Concrete Specimens
The freeze/thaw durability and the air void analysis take a significant amount of time to perform. It will take approximately 85 days to perform freeze/thaw testing on a concrete beam. The test requires a 35-day curing time and 50 days of freeze/thaw cycling. Air void analysis will take approximately 12 hours per specimen.

December 2000-January 2001: Data Analysis and Reporting
Test results collected both from the field and the laboratory will be compared in order to determine potential benefits of adding water reducers to PCCP mixes. A final report summarizing this investigation will be completed in January 2001.

Staffing

Laboratory Trial Mixing
Jason Blomberg, Int. R&D Assistant
John Schaefer, R&D Assistant
Steve Clark, Int. R&D Tech.

Field Sampling
Eric Burks, Sr. R&D Tech.
Larry Diaz, R&D Tech.
Stowe Johnson, R&D Assistant
Chris Graham, R&D Technician

Laboratory Mixing
Jason Blomberg, Int. R&D Assist.
John Schaefer, R&D Assist.
Steve Clark, Int. R&D Tech.

Permeability Testing
Jeff Joens, Sr. R&D Tech

Air Void Analysis
Nelson Cook, Int. R&D Assist.

Equipment
Air meter – RD&T inventory
Slump cone-RD&T inventory
Concrete Mixer & Supplies-RD&T, Phy. Lab inventory
Compression machine-Phy. Lab inventory
Freeze/Thaw machine-Phy. Lab inventory
Linear Traverse/Image Analysis-RD&T inventory
Permeability equipment-RD&T inventory
R&D Truck-RD&T inventory

Budget

Trial Mixing

Item	**No.**	*****	**Unit Cost**	*****	**Units**	*****	**Benefits**	**=**	**Subtotal**
Int. R&D Assistant	1		18.62		40		1.67		1243.82
R&D Assistant	1		18.26		40		1.67		1219.77
Int. R&D Technician	1		14.71		40		1.67		982.63

Laboratory Mixing and Sampling

Item	**No.**	*****	**Unit Cost**	*****	**Units**	*****	**Benefits**	**=**	**Subtotal**
Int. R&D Assistant	1		18.62		80		1.67		2487.63
R&D Assistant	1		18.26		80		1.67		2439.54
Sr. R&D Technician	1		16.22		80		1.67		2166.99
Int. R&D Technician	1		14.71		80		1.67		1965.26
R&D Technician	1		12.81		80		1.67		1711.42

Field Sampling

Item	**No.**	*****	**Unit Cost**	*****	**Units**	*****	**Benefits**	**=**	**Subtotal**
R&D Assistant	1		18.62		40		1.67		1243.82
Sr. R&D Technician	1		16.22		40		1.67		1083.50
R&D Technician	2		12.81		40		1.67		1711.42

Sample Testing

Item	**No.**	*****	**Unit Cost**	*****	**Units**	*****	**Benefits**	**=**	**Subtotal**
Int. R&D Assistant	1		18.62		182		1.67		5659.36
Sr. R&D Technician	1		16.22		98		1.67		2654.56
Physical Lab Technician	3		15.29		60		1.67		4596.17
Physical Lab Technician	1		15.29		30		1.67		766.03

Report and Presentation

Item	**No.**	*****	**Unit Cost**	*****	**Units**	*****	**Benefits**	**=**	**Subtotal**
Int. R&D Assistant	1		18.62		100		1.67		3109.54

GRAND TOTAL **$35,000**

APPENDIX B

Laboratory Concrete Batch Sheets

CONCRETE BATCHING PROGRAM

CONTROL MIX
BATCH A

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

W/C Ratio: 0.410

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
CEMENT	3.15	6.20			0.1098	21.59	32.38	Lbs.(Cement)
DESIGN WATER			4.62		0.1419	9.37	14.05	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.3067			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2912	0.2912	47.84	47.89	0.10	0.2	71.76	71.84	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4021	0.4021	0.10	0.8	66.50	66.56	99.84	
	2.650	100.0		0.4021	0	1	66.50	66.56	99.84	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.964	Lbs.
Wgt. of Conc.\Cu Ft =	145.77	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	153.75	Lbs.
% Air =	5.19	
Slump =	2.25	in.

AIR METER:

	Run 1	Run 2
Reading =	5.6	5.6
Aggr.Corr =	0.3	0.3
%Air =	5.3	5.3

WATER REDUCER:

0.000	OZ/SK
0.000	CC

AIR AGENT:

0.380	OZ/SK
3.871	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

							SCALE
W/C Ratio	0.410	SACKS				SCALE	WEIGHT
		PER	DESIGN	DESIGN	ABSOLUTE	WEIGHT	1.50
	SP. GR.	YD^3	GAL/SACK	AIR	VOLUME	(1.0 Ft^3)	(Ft^3)
CEMENT	3.15	6.20			0.1098	21.59	32.38 Lbs.(Cement)
DESIGN WATER			4.62		0.1419	9.37	14.05 Lbs.(Water)
DESIGN AIR				5.5	0.0550		
					0.3067		

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)
2.633	0.2912	0.2912	47.84	47.89	0.10	0.2	71.76	71.84 Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)
1" - #4	2.650	100.0	0.4021	0.4021	0.10	0.8	66.50	66.56	99.84
	2.650	100.0		0.4021	0	1	66.50	66.56	99.84 Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.748	Lbs.
Wgt. of Conc.\Cu Ft =	144.91	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	153.75	Lbs.
% Air =	5.75	
Slump =	2.25	in.

AIR METER:	Run 1	Run 2
Reading =	6.0	6.0
Aggr.Corr =	0.3	0.3
%Air =	5.7	5.7

WATER REDUCER:

0.000	OZ/SK
0.000	CC

AIR AGENT:

0.400	OZ/SK
4.075	CC

CONCRETE BATCHING PROGRAM J:\BLOMBJ\RI00-001\60\M3a620.XLS

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3
GRADATION "D"

W/C Ratio	0.410						SCALE WEIGHT 1.50	
	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	(Ft^3)	
CEMENT	3.15	6.20			0.1098	21.59	32.38	Lbs.(Cement)
DESIGN WATER			4.62		0.1419	9.37	14.05	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.3067			

MISSOURI RIVER - CAPITIAL SAND #1
SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2912	0.2912	47.84	47.89	0.10	0.2	71.76	71.84	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4021	0.4021	0.10	0.8	66.50	66.56	99.84	
	2.650	100.0		0.4021	0	1	66.50	66.56	99.84	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl = 43.975 Lbs.
Wgt. of Conc.\Cu Ft = 145.81 Lbs.
Wgt. of Bowl = 7.5360 Lbs.
Vol. of Bowl = 0.2499 Cu Ft
Voidless Den. = 153.75 Lbs.

% Air = 5.16

Slump = 2.25 in.

AIR METER:	Run 1	Run 2
Reading =	5.6	5.6
Aggr.Corr =	0.3	0.3
%Air =	5.3	5.3

WATER REDUCER:
0.000 OZ/SK
0.000 CC

AIR AGENT:
0.380 OZ/SK
3.871 CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
W/C Ratio	0.415							
CEMENT	3.15	6.00			0.1063	20.89	31.33	Lbs.(Cement)
DESIGN WATER			4.68		0.1390	9.19	13.78	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.3002			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2939	0.2939	48.29	48.34	0.10	0.2	72.43	72.50	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4059	0.4059	0.10	0.8	67.11	67.18	100.77	
	2.650	100.0		0.4059	0	1	67.11	67.18	100.77	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.932	Lbs.
Wgt. of Conc.\Cu Ft =	145.64	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	153.95	Lbs.
% Air =	5.39	
Slump =	2.00	in.

AIR METER:	Run 1	Run 2
Reading =	5.5	5.5
Aggr.Corr =	0.3	0.3
%Air =	5.2	5.2

WATER REDUCER:

0.000	OZ/SK
0.000	CC

AIR AGENT:

0.400	OZ/SK
3.943	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3
GRADATION "D"

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
W/C Ratio	0.415							
CEMENT	3.15	6.00			0.1063	20.89	31.33	Lbs.(Cement)
DESIGN WATER			4.68		0.1390	9.19	13.78	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.3002			

MISSOURI RIVER - CAPITIAL SAND #1
SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2939	0.2939	48.29	48.34	0.10	0.2	72.43	72.50	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4059	0.4059	0.10	0.8	67.11	67.18	100.77	
	2.650	100.0		0.4059	0	1	67.11	67.18	100.77	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl = 44.037 Lbs.
Wgt. of Conc.\Cu Ft = 146.06 Lbs.
Wgt. of Bowl = 7.5360 Lbs.
Vol. of Bowl = 0.2499 Cu Ft
Voidless Den. = 153.95 Lbs.

% Air = 5.12

Slump = 2.00 in.

AIR METER:	Run 1	Run 2
Reading =	5.6	5.6
Aggr.Corr =	0.3	0.3
%Air =	5.3	5.3

WATER REDUCER:
0.000 OZ/SK
0.000 CC

AIR AGENT:
0.400 OZ/SK
3.943 CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio: 0.415

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
CEMENT	3.15	6.00			0.1063	20.89	31.33	Lbs.(Cement)
DESIGN WATER			4.68		0.1390	9.19	13.78	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.3002			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2939	0.2939	48.29	48.34	0.10	0.2	72.43	72.50	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4059	0.4059	0.10	0.8	67.11	67.18	100.77	
	2.650	100.0		0.4059	0	1	67.11	67.18	100.77	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.886	Lbs.
Wgt. of Conc.\Cu Ft =	145.46	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	153.95	Lbs.
% Air =	5.51	
Slump =	1.75	in.

AIR METER:	Run 1	Run 2
Reading =	5.9	5.9
Aggr.Corr =	0.3	0.3
%Air =	5.6	5.6

WATER REDUCER:

0.000	OZ/SK
0.000	CC

AIR AGENT:

0.400	OZ/SK
3.943	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

							SCALE	
W/C Ratio	0.400	SACKS				SCALE	WEIGHT	
		PER	DESIGN	DESIGN	ABSOLUTE	WEIGHT	1.50	
	SP. GR.	YD^3	GAL/SACK	AIR	VOLUME	(1.0 Ft^3)	(Ft^3)	
CEMENT	3.15	6.00			0.1063	20.89	31.33	Lbs.(Cement)
DESIGN WATER			4.51		0.1339	8.88	13.32	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2952			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2960	0.2960	48.63	48.68	0.10	0.2	72.95	73.02	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4088	0.4088	0.10	0.8	67.60	67.66	101.49	
	2.650	100.0		0.4088	0	1	67.60	67.66	101.49	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	44.100	Lbs.
Wgt. of Conc.\Cu Ft =	146.31	Lbs.
Wgt. of Bowl =	7.5360	Lbs. - Meter HA25129
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	154.50	Lbs.
% Air =	5.30	
Slump =	1.75	in.

AIR METER:	Run 1	Run 2
Reading =	5.8	5.8
Aggr.Corr =	0.3	0.3
%Air =	5.5	5.5

WATER REDUCER:

3.000	OZ/SK
29.574	CC

AIR AGENT:

0.230	OZ/SK
2.267	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio: 0.400

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
CEMENT	3.15	6.00			0.1063	20.89	31.33	Lbs.(Cement)
DESIGN WATER			4.51		0.1339	8.88	13.32	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2952			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2960	0.2960	48.63	48.68	0.10	0.2	72.95	73.02	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4088	0.4088	0.10	0.8	67.60	67.66	101.49	
	2.650	100.0		0.4088	0	1	67.60	67.66	101.49	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	44.056	Lbs.
Wgt. of Conc.\Cu Ft =	146.14	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	154.50	Lbs.
% Air =	5.41	
Slump =	2.00	in.

AIR METER:

	Run 1	Run 2
Reading =	5.8	5.8
Aggr.Corr =	0.3	0.3
%Air =	5.5	5.5

WATER REDUCER:

3.000	OZ/SK
29.574	CC

AIR AGENT:

0.230	OZ/SK
2.267	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio 0.400

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
CEMENT	3.15	6.00			0.1063	20.89	31.33	Lbs.(Cement)
DESIGN WATER			4.51		0.1339	8.88	13.32	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2952			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2960	0.2960	48.63	48.68	0.10	0.2	72.95	73.02	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4088	0.4088	0.10	0.8	67.60	67.66	101.49	
	2.650	100.0		0.4088	0	1	67.60	67.66	101.49	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl = 44.018 Lbs.

Wgt. of Conc.\Cu Ft = 145.99 Lbs.

Wgt. of Bowl = 7.5360 Lbs. - Meter HA25129

Vol. of Bowl = 0.2499 Cu Ft

Voidless Den. = 154.50 Lbs.

% Air = 5.51

Slump = 1.75 in.

AIR METER:	Run 1	Run 2
Reading =	5.8	5.8
Aggr.Corr =	0.3	0.3
%Air =	5.5	5.5

WATER REDUCER:

3.000 OZ/SK

29.574 CC

AIR AGENT:

0.230 OZ/SK

2.267 CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio: 0.405

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
CEMENT	3.15	6.00			0.1063	20.89	31.33	Lbs.(Cement)
DESIGN WATER			4.56		0.1356	8.98	13.48	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2969			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2953	0.2953	48.52	48.57	0.10	0.2	72.78	72.85	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4078	0.4078	0.10	0.8	67.43	67.50	101.25	
	2.650	100.0		0.4078	0	1	67.43	67.50	101.25	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl = 43.724 Lbs.

Wgt. of Conc.\Cu Ft = 144.81 Lbs.

Wgt. of Bowl = 7.5360 Lbs.

Vol. of Bowl = 0.2499 Cu Ft

Voidless Den. = 154.31 Lbs.

% Air = 6.16

Slump = 2.25 in.

AIR METER:	Run 1	Run 2
Reading =	6.6	6.6
Aggr.Corr =	0.3	0.3
%Air =	6.3	6.3

WATER REDUCER:

5.000 OZ/SK

49.289 CC

AIR AGENT:

0.125 OZ/SK

1.232 CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio: 0.410

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	WEIGHT 1.50 (Ft^3)	
CEMENT	3.15	6.00			0.1063	20.89	31.33	Lbs.(Cement)
DESIGN WATER			4.62		0.1373	8.75	13.13	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2986			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2946	0.2946	48.40	48.45	0.10	0.2	72.60	72.68	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4068	0.4068	0.80	1.0	67.27	67.81	101.72	
	2.650	100.0		0.4068	1	1	67.27	67.81	101.72	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.866	Lbs.
Wgt. of Conc.\Cu Ft =	145.38	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	153.77	Lbs.
% Air =	5.46	
Slump =	2.25	in.

AIR METER:	Run 1	Run 2
Reading =	6.0	6.0
Aggr.Corr =	0.3	0.3
%Air =	5.7	5.7

WATER REDUCER:

5.000	OZ/SK
49.289	CC

AIR AGENT:

0.125	OZ/SK
1.232	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio: 0.400

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
CEMENT	3.15	6.00			0.1063	20.89	31.33	Lbs.(Cement)
DESIGN WATER			4.51		0.1339	8.88	13.32	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2952			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2960	0.2960	48.63	48.68	0.10	0.2	72.95	73.02	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4088	0.4088	0.10	0.8	67.60	67.66	101.49	
	2.650	100.0		0.4088	0	1	67.60	67.66	101.49	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.702	Lbs.
Wgt. of Conc.\Cu Ft =	144.72	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	154.50	Lbs.
% Air =	6.33	
Slump =	1.75	in.

AIR METER:

	Run 1	Run 2
Reading =	6.8	6.8
Aggr.Corr =	0.3	0.3
%Air =	6.5	6.5

WATER REDUCER:

5.000	OZ/SK
49.289	CC

AIR AGENT:

0.125	OZ/SK
1.232	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio: 0.430

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
CEMENT	3.15	5.80			0.1027	20.19	30.29	Lbs.(Cement)
DESIGN WATER			4.85		0.1392	9.21	13.81	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2969			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2953	0.2953	48.52	48.57	0.10	0.2	72.78	72.85	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4078	0.4078	0.10	0.8	67.43	67.50	101.25	
	2.650	100.0		0.4078	0	1	67.43	67.50	101.25	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.936	Lbs.
Wgt. of Conc.\Cu Ft =	145.66	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	153.81	Lbs.
% Air =	5.30	
Slump =	2.25	in.

AIR METER:	Run 1	Run 2
Reading =	5.8	5.8
Aggr.Corr =	0.3	0.3
%Air =	5.5	5.5

WATER REDUCER:		AIR AGENT:	
0.000	OZ/SK	0.380	OZ/SK
0.000	CC	3.621	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio	0.430	SACKS				SCALE	WEIGHT	
		PER	DESIGN	DESIGN	ABSOLUTE	WEIGHT	1.50	
	SP. GR.	YD^3	GAL/SACK	AIR	VOLUME	(1.0 Ft^3)	(Ft^3)	
CEMENT	3.15	5.80			0.1027	20.19	30.29	Lbs.(Cement)
DESIGN WATER			4.85		0.1392	9.21	13.81	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2969			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2953	0.2953	48.52	48.57	0.10	0.2	72.78	72.85	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4078	0.4078	0.10	0.8	67.43	67.50	101.25	
	2.650	100.0		0.4078	0	1	67.43	67.50	101.25	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.966	Lbs.
Wgt. of Conc.\Cu Ft =	145.78	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	153.81	Lbs.
% Air =	5.22	
Slump =	2.00	in.

AIR METER:	Run 1	Run 2
Reading =	5.7	5.7
Aggr.Corr =	0.3	0.3
%Air =	5.4	5.4

WATER REDUCER:

0.000	OZ/SK
0.000	CC

AIR AGENT:

0.380	OZ/SK
3.621	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio: 0.430

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
CEMENT	3.15	5.80			0.1027	20.19	30.29	Lbs.(Cement)
DESIGN WATER			4.85		0.1392	9.21	13.81	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2969			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2953	0.2953	48.52	48.57	0.10	0.2	72.78	72.85	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4078	0.4078	0.10	0.8	67.43	67.50	101.25	
	2.650	100.0		0.4078	0	1	67.43	67.50	101.25	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl = 43.736 Lbs.

Wgt. of Conc.\Cu Ft = 144.86 Lbs.

Wgt. of Bowl = 7.5360 Lbs.

Vol. of Bowl = 0.2499 Cu Ft

Voidless Den. = 153.81 Lbs.

% Air = 5.82

Slump = 2.00 in.

AIR METER:	Run 1	Run 2
Reading =	6.2	6.2
Aggr.Corr =	0.3	0.3
%Air =	5.9	5.9

WATER REDUCER:

0.000 OZ/SK

0.000 CC

AIR AGENT:

0.400 OZ/SK

3.812 CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio 0.415	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
CEMENT	3.15	5.80			0.1027	20.19	30.29	Lbs.(Cement)
DESIGN WATER			4.68		0.1343	8.91	13.36	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2921			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2973	0.2973	48.85	48.90	0.10	0.2	73.28	73.35	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4106	0.4106	0.10	0.8	67.90	67.97	101.95	
	2.650	100.0		0.4106	0	1	67.90	67.97	101.95	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.744	Lbs.
Wgt. of Conc.\Cu Ft =	144.89	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	154.34	Lbs.
% Air =	6.12	
Slump =	2.00	in.

AIR METER:	Run 1	Run 2
Reading =	6.1	6.1
Aggr.Corr =	0.3	0.3
%Air =	5.8	5.8

WATER REDUCER:

3.000	OZ/SK
28.588	CC

AIR AGENT:

0.250	OZ/SK
2.382	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio	0.415						
	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)
CEMENT	3.15	5.80			0.1027	20.19	30.29 Lbs.(Cement)
DESIGN WATER			4.68		0.1343	8.91	13.36 Lbs.(Water)
DESIGN AIR				5.5	0.0550		
					0.2921		

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)
2.633	0.2973	0.2973	48.85	48.90	0.10	0.2	73.28	73.35 Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)
1" - #4	2.650	100.0	0.4106	0.4106	0.10	0.8	67.90	67.97	101.95
	2.650	100.0		0.4106	0	1	67.90	67.97	101.95 Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.808	Lbs.
Wgt. of Conc.\Cu Ft =	145.15	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	154.34	Lbs.
% Air =	5.96	
Slump =	2.25	in.

AIR METER:	Run 1	Run 2
Reading =	6.2	6.2
Aggr.Corr =	0.3	0.3
%Air =	5.9	5.9

WATER REDUCER:

3.000	OZ/SK
28.588	CC

AIR AGENT:

0.250	OZ/SK
2.382	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3
GRADATION "D"

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
W/C Ratio	0.425							
CEMENT	3.15	5.80			0.1027	20.19	30.29	Lbs.(Cement)
DESIGN WATER			4.79		0.1376	9.11	13.66	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2953			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2960	0.2960	48.63	48.68	0.10	0.2	72.94	73.02	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4087	0.4087	0.10	0.8	67.59	67.65	101.48	
	2.650	100.0		0.4087	0	1	67.59	67.65	101.48	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.610	Lbs.
Wgt. of Conc.\Cu Ft =	144.35	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	153.98	Lbs.
% Air =	6.25	
Slump =	2.25	in.

AIR METER:	Run 1	Run 2
Reading =	6.4	6.4
Aggr.Corr =	0.3	0.3
%Air =	6.1	6.1

WATER REDUCER:		AIR AGENT:	
3.000	OZ/SK	0.250	OZ/SK
28.588	CC	2.382	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio: 0.410

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
CEMENT	3.15	5.80			0.1027	20.19	30.29	Lbs.(Cement)
DESIGN WATER			4.62		0.1327	8.81	13.21	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2904			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2980	0.2980	48.96	49.01	0.10	0.2	73.45	73.52	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4115	0.4115	0.10	0.8	68.05	68.12	102.18	
	2.650	100.0		0.4115	0	1	68.05	68.12	102.18	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.742	Lbs.
Wgt. of Conc.\Cu Ft =	144.88	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	154.51	Lbs.
% Air =	6.23	
Slump =	2.25	in.

AIR METER:	Run 1	Run 2
Reading =	6.4	6.3
Aggr.Corr =	0.3	0.3
%Air =	6.1	6.0

WATER REDUCER:	
5.000	OZ/SK
47.646	CC

AIR AGENT:	
0.125	OZ/SK
1.191	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio: 0.410

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
CEMENT	3.15	5.80			0.1027	20.19	30.29	Lbs.(Cement)
DESIGN WATER			4.62		0.1327	8.81	13.21	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2904			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2980	0.2980	48.96	49.01	0.10	0.2	73.45	73.52	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4115	0.4115	0.10	0.8	68.05	68.12	102.18	
	2.650	100.0		0.4115	0	1	68.05	68.12	102.18	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.696	Lbs.
Wgt. of Conc.\Cu Ft =	144.70	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	154.51	Lbs.
% Air =	6.35	
Slump =	2.25	in.

AIR METER:	Run 1	Run 2
Reading =	6.4	6.4
Aggr.Corr =	0.3	0.3
%Air =	6.1	6.1

WATER REDUCER:

5.000	OZ/SK
47.646	CC

AIR AGENT:

0.125	OZ/SK
1.191	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

							SCALE	
W/C Ratio	0.405	SACKS				SCALE	WEIGHT	
		PER	DESIGN	DESIGN	ABSOLUTE	WEIGHT	1.50	
	SP. GR.	YD^3	GAL/SACK	AIR	VOLUME	(1.0 Ft^3)	(Ft^3)	
CEMENT	3.15	5.80			0.1027	20.19	30.29	Lbs.(Cement)
DESIGN WATER			4.56		0.1311	8.71	13.06	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2888			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

								SCALE	
							WEIGHT	WEIGHT	
			WEIGHT	WEIGHT			(DRY)	(AIR DRY)	
SP. GR.	DESIGN	ABSOLUTE	(DRY)	(AIR DRY)	PERCENT	PERCENT	1.50	1.50	
(DRY)	ABS. VOL.	VOLUME	(1.0 FT^3)	(1.0 FT^3)	MOIST.	ABSORP.	(FT^3)	(FT^3)	
2.633	0.2987	0.2987	49.08	49.12	0.10	0.2	73.61	73.69	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

									SCALE	
									WEIGHTS	
							WEIGHT	WEIGHT	(AIR DRY)	
	SP. GR.	PERCENT	DESIGN	ABSOLUTE	PERCENT	PERCENT	(DRY)	(AIR DRY)	1.50	
FRACTION	(DRY)	CA FRACT.	ABS. VOL.	VOLUME	MOIST.	ABSORP.	(1.0 FT^3)	(1.0 FT^3)	(FT^3)	
1" - #4	2.650	100.0	0.4125	0.4125	0.10	0.8	68.21	68.28	102.41	
	2.650	100.0		0.4125	0	1	68.21	68.28	102.41	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.952	Lbs.
Wgt. of Conc.\Cu Ft =	145.72	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	154.69	Lbs.
% Air =	5.80	
Slump =	2.00	in.

AIR METER:

	Run 1	Run 2
Reading =	6.2	6.2
Aggr.Corr =	0.3	0.3
%Air =	5.9	5.9

WATER REDUCER:

5.000	OZ/SK
47.646	CC

AIR AGENT:

0.125	OZ/SK
1.191	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio: 0.445

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
CEMENT	3.15	5.60			0.0992	19.50	29.24	Lbs.(Cement)
DESIGN WATER			5.02		0.1391	9.20	13.80	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2933			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2968	0.2968	48.77	48.82	0.10	0.2	73.15	73.23	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4099	0.4099	0.10	0.8	67.78	67.85	101.78	
	2.650	100.0		0.4099	0	1	67.78	67.85	101.78	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl = 43.650 Lbs.

Wgt. of Conc.\Cu Ft = 144.51 Lbs.

Wgt. of Bowl = 7.5360 Lbs.

Vol. of Bowl = 0.2499 Cu Ft

Voidless Den. = 153.70 Lbs.

% Air = 5.98

Slump = 2.25 in.

AIR METER:	Run 1	Run 2
Reading =	6.2	6.2
Aggr.Corr =	0.3	0.3
%Air =	5.9	5.9

WATER REDUCER:

0.000 OZ/SK

0.000 CC

AIR AGENT:

0.400 OZ/SK

3.680 CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio: 0.440

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
CEMENT	3.15	5.60			0.0992	19.50	29.24	Lbs.(Cement)
DESIGN WATER			4.96		0.1375	9.11	13.66	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2917			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2975	0.2975	48.88	48.93	0.10	0.2	73.32	73.39	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4108	0.4108	0.10	0.8	67.93	68.00	102.00	
	2.650	100.0		0.4108	0	1	67.93	68.00	102.00	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.870	Lbs.
Wgt. of Conc.\Cu Ft =	145.39	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	153.87	Lbs.
% Air =	5.51	
Slump =	1.75	in.

AIR METER:	Run 1	Run 2
Reading =	6.0	6.0
Aggr.Corr =	0.3	0.3
%Air =	5.7	5.7

WATER REDUCER:

0.000	OZ/SK
0.000	CC

AIR AGENT:

0.350	OZ/SK
3.220	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio: 0.440

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
CEMENT	3.15	5.60			0.0992	19.50	29.24	Lbs.(Cement)
DESIGN WATER			4.96		0.1375	9.11	13.66	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2917			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2975	0.2975	48.88	48.93	0.10	0.2	73.32	73.39	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4108	0.4108	0.10	0.8	67.93	68.00	102.00	
	2.650	100.0		0.4108	0	1	67.93	68.00	102.00	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.792	Lbs.
Wgt. of Conc.\Cu Ft =	145.08	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	153.87	Lbs.
% Air =	5.71	
Slump =	2.00	in.

AIR METER:	Run 1	Run 2
Reading =	6.1	6.0
Aggr.Corr =	0.3	0.3
%Air =	5.8	5.7

WATER REDUCER:

0.000	OZ/SK
0.000	CC

AIR AGENT:

0.380	OZ/SK
3.496	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
W/C Ratio	0.430							
CEMENT	3.15	5.60			0.0992	19.50	29.24	Lbs.(Cement)
DESIGN WATER			4.85		0.1344	8.91	13.37	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2886			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2988	0.2988	49.09	49.14	0.10	0.2	73.64	73.71	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4126	0.4126	0.10	0.8	68.23	68.30	102.45	
	2.650	100.0		0.4126	0	1	68.23	68.30	102.45	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	44.060	Lbs.
Wgt. of Conc.\Cu Ft =	146.15	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	154.22	Lbs.
% Air =	5.23	
Slump =	2.25	in.

AIR METER:

	Run 1	Run 2
Reading =	5.7	5.7
Aggr.Corr =	0.3	0.3
%Air =	5.4	5.4

WATER REDUCER:

3.000	OZ/SK
27.602	CC

AIR AGENT:

0.200	OZ/SK
1.840	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio: 0.430

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
CEMENT	3.15	5.60			0.0992	19.50	29.24	Lbs.(Cement)
DESIGN WATER			4.85		0.1344	8.91	13.37	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2886			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2988	0.2988	49.09	49.14	0.10	0.2	73.64	73.71	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4126	0.4126	0.10	0.8	68.23	68.30	102.45	
	2.650	100.0		0.4126	0	1	68.23	68.30	102.45	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.766	Lbs.
Wgt. of Conc.\Cu Ft =	144.98	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	154.22	Lbs.
% Air =	5.99	
Slump =	2.25	in.

AIR METER:

	Run 1	Run 2
Reading =	6.2	6.3
Aggr.Corr =	0.3	0.3
%Air =	5.9	6.0

WATER REDUCER:

3.000	OZ/SK
27.602	CC

AIR AGENT:

0.200	OZ/SK
1.840	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

							SCALE WEIGHT 1.50	
W/C Ratio	0.430	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	(Ft^3)	
	SP. GR.							
CEMENT	3.15	5.60			0.0992	19.50	29.24	Lbs.(Cement)
DESIGN WATER			4.85		0.1344	8.91	13.37	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2886			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.2988	0.2988	49.09	49.14	0.10	0.2	73.64	73.71	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4126	0.4126	0.10	0.8	68.23	68.30	102.45	
	2.650	100.0		0.4126	0	1	68.23	68.30	102.45	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.800	Lbs.
Wgt. of Conc.\Cu Ft =	145.11	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	154.22	Lbs.
% Air =	5.90	
Slump =	2.00	in.

AIR METER:	Run 1	Run 2
Reading =	6.0	6.0
Aggr.Corr =	0.3	0.3
%Air =	5.7	5.7

WATER REDUCER:		AIR AGENT:	
3.000	OZ/SK	0.180	OZ/SK
27.602	CC	1.656	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio: 0.415

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
CEMENT	3.15	5.60			0.0992	19.50	29.24	Lbs.(Cement)
DESIGN WATER			4.68		0.1297	8.62	12.94	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2839			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.3008	0.3008	49.42	49.47	0.10	0.2	74.12	74.20	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4153	0.4153	0.10	0.8	68.68	68.75	103.13	
	2.650	100.0		0.4153	0	1	68.68	68.75	103.13	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.822	Lbs.
Wgt. of Conc.\Cu Ft =	145.20	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	154.73	Lbs.
% Air =	6.16	
Slump =	2.00	in.

AIR METER:

	Run 1	Run 2
Reading =	6.5	6.5
Aggr.Corr =	0.3	0.3
%Air =	6.2	6.2

WATER REDUCER:

5.000	OZ/SK
46.003	CC

AIR AGENT:

0.125	OZ/SK
1.150	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio: 0.410

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
CEMENT	3.15	5.60			0.0992	19.50	29.24	Lbs.(Cement)
DESIGN WATER			4.62		0.1281	8.53	12.79	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2823			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.3014	0.3014	49.52	49.57	0.10	0.2	74.29	74.36	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4163	0.4163	0.10	0.8	68.83	68.90	103.35	
	2.650	100.0		0.4163	0	1	68.83	68.90	103.35	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.878	Lbs.
Wgt. of Conc.\Cu Ft =	145.43	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	154.90	Lbs.
% Air =	6.12	
Slump =	1.75	in.

AIR METER:	Run 1	Run 2
Reading =	6.2	6.2
Aggr.Corr =	0.3	0.3
%Air =	5.9	5.9

WATER REDUCER:		AIR AGENT:	
5.000	OZ/SK	0.125	OZ/SK
46.003	CC	1.150	CC

CONCRETE BATCHING PROGRAM

COARSE AGGREGATE: CEDAR VALLEY, CAPITAL QUARRY 1A, HOLT SUMMIT, LEDGES 1-3

GRADATION "D"

W/C Ratio: 0.415

	SP. GR.	SACKS PER YD^3	DESIGN GAL/SACK	DESIGN AIR	ABSOLUTE VOLUME	SCALE WEIGHT (1.0 Ft^3)	SCALE WEIGHT 1.50 (Ft^3)	
CEMENT	3.15	5.60			0.0992	19.50	29.24	Lbs.(Cement)
DESIGN WATER			4.68		0.1297	8.62	12.94	Lbs.(Water)
DESIGN AIR				5.5	0.0550			
					0.2839			

MISSOURI RIVER - CAPITIAL SAND #1

SAND: % Sand= 42.0

SP. GR. (DRY)	DESIGN ABS. VOL.	ABSOLUTE VOLUME	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) 1.50 (FT^3)	SCALE WEIGHT (AIR DRY) 1.50 (FT^3)	
2.633	0.3008	0.3008	49.42	49.47	0.10	0.2	74.12	74.20	Lbs.(Sand)

COARSE AGGREGATE (AIR DRIED):

FRACTION	SP. GR. (DRY)	PERCENT CA FRACT.	DESIGN ABS. VOL.	ABSOLUTE VOLUME	PERCENT MOIST.	PERCENT ABSORP.	WEIGHT (DRY) (1.0 FT^3)	WEIGHT (AIR DRY) (1.0 FT^3)	SCALE WEIGHTS (AIR DRY) 1.50 (FT^3)	
1" - #4	2.650	100.0	0.4153	0.4153	0.10	0.8	68.68	68.75	103.13	
	2.650	100.0		0.4153	0	0.80	68.68	68.75	103.13	Lbs.(CA)

VOLUMETRIC AIR:

Wgt. of Conc.+ Bowl =	43.790	Lbs.
Wgt. of Conc.\Cu Ft =	145.07	Lbs.
Wgt. of Bowl =	7.5360	Lbs.
Vol. of Bowl =	0.2499	Cu Ft
Voidless Den. =	154.73	Lbs.
% Air =	6.24	
Slump =	1.75	In.

AIR METER:

	Run 1	Run 2
Reading =	6.3	6.3
Aggr.Corr =	0.3	0.3
%Air =	6.0	6.0

WATER REDUCER:

5.000	OZ/SK
46.003	CC

AIR AGENT:

0.125	OZ/SK
1.150	CC

APPENDIX C

Laboratory and Field Testing
Results and Mix Characteristics

LABORATORY TESTING RESULTS

LABORATORY RESULTS- PCCP MIXES CONTAINING DIFFERENT COMBINATIONS OF WATER REDUCRE DOSAGES AND DECREASED CEMENT CONTENT COMPARED TO A STANDARD (CONTROL) PCCP MIX

CONTROL	Cement (Sacks/yd^3)	Air Agent (oz/sack)	WR (oz/sack)	W/C Ratio	Slump (in)	Air (%)	7-Day Compress. Strength	28-Day Compress. Strength	28-Day Flexural Strength	F/T Durability	F/T Wt. Change	F/T Length Change	F/T Flexural Strength	Chloride Permeability
BATCH A	6.20	0.380	0	0.410	2.25	5.30	4270	5580	974	95	0.202	0.0088	913	2351
BATCH B	6.20	0.400	0	0.410	2.25	5.70	3970	5700	864	95.8	0.07	0.0019	765	2482
BATCH C	6.20	0.380	0	0.410	2.25	5.30	4340	5810	895	96.32	0.122	0.0006	823	4294
	Average	0.387	0	0.410	2.25	5.4	4193	5697	911	95.71	0.13	0.00	834	3042
Standard	**Deviation**						197	115	57	0.6649	0.0665	0.0044	75	1086

MIX 2	Cement (Sacks/yd^3)	Air Agent (oz/sack)	WR (oz/sack)	Ratio	Slump (in)	Air (%)	7-Day Compress. Strength	28-Day Compress. Strength	28-Day Flexural Strength	F/T Durability	F/T Change	F/T Length Change		Chloride Per
Batch A	6.00	0.400	0	0.415	2.00	5.20	4390	6070	918	96.34	0.092	0.0031	873	3778
Batch B	6.00	0.400	0	0.415	2.00	5.30	4180	5830	914	95.7	0.12	0.005	867	4379
Batch C	6.00	0.400	0	0.415	1.75	5.60	4170	5710	966	94.5	0.16	0.009	829	4241
	Average	0.400	0	0.415	1.92	5.4	4247	5870	933	95.51	0.12	0.01	856	4133
Standard	**Deviation**						124	183	29	0.9341	0.0342	0.0030	24	315

MIX 3	Cement (Sacks/yd^3)	Air Agent (oz/sack)	(oz/sack)	W/C Ratio	(in)	Air (%)	7-Day Compress. Strength	Compress. Strength	28-Day Flexural Strength	F/T Durability	F/T Wt. Change	F/T Length Change	F/T Flexural Strength	Chloride Permeability
BATCH A	6.00	0.230	3	0.400	1.75	5.50	4800	6320	891	95.12	0.115	0.0913	912	3172
BATCH B	6.00	0.230	3	0.400	2.00	5.50	4560	6080	951	95.6	0.118	0.0056	835	2247
BATCH C	6.00	0.250	3	0.410	2.25	6.10	4800	6290	904	95.83	0.132	0.0769	844	2550
	Average	0.237	3	0.403	2.00	5.7	4720	6230	915	95.52	0.12	0.06	864	2656
Standard	**Deviation**						139	131	32	0.3623	0.0091	0.0459	42	472

MIX 4	Cement (Sacks/yd^3)	(oz/sack)	WR (oz/sack)	W/C Ratio	Slump (in)	Air (%)	Compress.	28-Day Compress. Strength	28-Day Flexural Strength	F/T Durability	F/T Change	Length Change	F/T Flexural Strength	Chloride Permeability
BATCH A	6.00	0.125	5	0.405	2.25	6.30	4740	6480	884	95.5	0.17	0.007	n/a	4218
BATCH B	6.00	0.125	5	0.410	2.25	5.70	5000	6460	886	95.9	0.106	0.188	854	2223
BATCH C	6.00	0.125	5	0.400	1.75	6.50	4730	6310	859	94.9	0.118	0.015	852	2390
	Average	0.125	5	0.405	2.08	6.2	4823	6417	876	95.43	0.13	0.07	853	2944
Standard	**Deviation**						153	93	15	0.5033	0.0340	0.1023	1	1107

LABORATORY TESTING RESULTS (CONT…)

MIX 5	Cement (S 3)	Air Agent (oz/sack)	WR (oz/sack)	W/C Ratio	Slump (in)	Air (%)	7-Day Compress. Strength	28-Day Compress. Strength	28-Day Flexural Strength	F/T Durability	F/T Wt. Change		F/T Flexural Strength	Chloride Permeability
BATCH A	5.80	0.380	0	0.430	2.25	5.50	3970	5570	916	96.09	0.222	0.01	797	4432
BATCH B	5.80	0.380	0	0.430	2.00	5.40	4330	5830	889	94.38	0.208	0.0819	900	2555
BATCH C	5.80	0.400	0	0.430	2.00	5.90	4020	5520	928	95.4	0.22	0.014	794	3300
	Average	0.387	0	0.430	2.08	5.6	4107	5640	911	95.29	0.22	0.04	830	3429
Standard	**Deviation**						195	166	20	0.8603	0.0076	0.0404	60	945

	Cement (Sacks/yd^3)	Air Agent (oz/sack)	WR (oz/sack)	Ratio	Slump (in)	Air (%)	7-Day Compress. Strength	Compress. Strength	28-Day Flexural Strength	F/T Dur	F/T Wt. Change	F/T Length Change	F/T Flexural Strength	Chloride Permeability
BATCH A	5.80	0.250	3	0.415	2.00	5.80	4410	5910	975	94.8	0.2	0.004	832	3858
BATCH B	5.80	0.250	3	0.415	2.25	5.90	4340	5980	889	95.21	0.119	0.0006	748	4215
BATCH C	5.80	0.250	3	0.425	2.25	6.10	4480	6080	848	96.11	0.127	0.0006	857	2761
	Average	0.250	3	0.418	2.17	5.9	4410	5990	904	95.37	0.15	0.00	812	3611
Standard	**Deviation**						70	85	65	0.6701	0.0446	0.0020	57	758

MIX 7	Cement (Sacks/yd^3)		WR (oz/sack)	W/C Ratio	Slump (in)	Air (%)	7-Day Compress. Strength	28-Day Compress. Strength	Flexural Strength	F/T Durability	F/T Wt. Change	F/T Length	F/T Flexural Strength	Chloride Permeability
BATCH A	5.80	0.125	5	0.410	2.25	6.10	4710	6260	886	94.9	0.13	0.004	770	2713
BATCH B	5.80	0.125	5	0.410	2.25	6.10	4160	5680	968	96.8	0.08	0.028	952	2865
BATCH C	5.80	0.125	5	0.405	2.00	5.90	4750	6100	947	94.1	0.15	0.021	785	3308
	Average	0.125	5	0.408	2.17	6.0	4540	6013	934	95.27	0.12	0.02	836	2962
Standard	**Deviation**						330	300	43	1.3868	0.0361	0.0123	101	309

LABORATORY TESTING RESULTS (CONT…)

	Cement (Sacks/yd^3)	Air Agent (oz/sack)	WR (oz/sack)	W/C Ratio	Slump (in)	Air (%)	7-Day Compress.	28-Day Compress. Strength	28-Day Strength	F/T Durability	F/T Wt. Change	F/T Length Change	F/T Flexural Strength	Chloride Permeability
BATCH A	5.60	0.400	0	0.445	2.25	5.90	3970	5440	938	95.6	0.22	0.009	748	2787
BATCH B	5.60	0.350	0	0.440	1.75	5.70	4030	5470	837	95.5	0.163	0.0031	874	2655
BATCH C	5.60	0.380	0	0.440	2.00	5.70	3830	5650	871	95.4	0.151	0.005	875	2707
	Average	0.377	0	0.442	2.00	5.8	3943	5520	882	95.50	0.18	0.01	832	2716
Standard	**Deviation**						103	114	51	0.1000	0.0369	0.0030	73	66

MIX 9	Cement (S 3)	Air Agent (oz/sack)	WR (oz/sack)	W/C Ratio	Slump (in)	Air (%)	7-Day Strength	28-Day Compress. Strength	Flexural Strength	F/T Durability	Wt. Change	F/T Length Change	F/T Flexural Strength	Chloride Permeability
BATCH A	5.60	0.200	3	0.430	2.25	5.40	4370	6080	908	95.3	0.777	0.0006	894	2507
BATCH B	5.60	0.200	3	0.430	2.25	6.00	3960	5490	885	100	0.07	0.019	872	2863
BATCH C	5.60	0.180	3	0.430	2.00	5.70	4410	6060		95.3	0.183	0.0819	854	3018
	Average	0.193	3	0.430	2.17	5.7	4247	5877	897	96.87	0.34	0.03	873	2796
Standard	**Deviation**						249	335	16	2.7135	0.3798	0.0426	20	262

MIX 10	Cement (Sacks/yd^3)	(oz/sack)	WR (oz/sack)	W/C	(in)	Air (%)	7-Day Compress. Strength	28-Day Compress. Strength	28-Day Flexural Strength		F/T Wt. Change	Length Change	F/T Flexural Strength	Permeability
BATCH A	5.60	0.125	5	0.415	2.00	6.20	4120	5830	949	96.2	0.06	0.021	874	2849
BATCH B	5.60	0.125	5	0.410	1.75	5.90	4800	6470	840	95.8	0.12	0.006	865	2842
BATCH C	5.60	0.125	5	0.415	1.75	6.00	4300	5730	925	96.3	0.2	0.01	853	2834
	Average	0.125	5	0.413	1.83	6.0	4407	6010	905	96.10	0.13	0.01	864	2842
Standard	**Deviation**						352	401	57	0.2646	0.0702	0.0078	11	8

FIELD TESTING RESULTS
CONTROL MIX RESULTS

Mix Name	Cement (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/sack)	W/C Ratio	Slump (in)	Air (%)	7-Day Compress. Strength	28-Day Compress. Strength	7-Day Flexural Strength	28-Day Flexural Strength	F/T Durability Factor	F/T %Wt. Change	F/T %Length Change	Chloride Permeability
Control Mix	572	0.0	9.3	0.366	2.00	6.30	4020	5112	633	690	50.28	0.421	0.2394	3533
Interval 1							4080	4973	658	633	49.63	0.4628	0.2119	
							4320	5200	589	685	-	-	-	
					Average		4140	5095	627	669	50	0.4419	0.2257	3533
					Std. Deviation		159	114	35	32				

Mix Name	Cement (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/sack)	W/C Ratio	Slump (in)	Air (%)	7-Day Compress. Strength	28-Day Compress. Strength	7-Day Flexural Strength	28-Day Flexural Strength	F/T Durability Factor	F/T %Wt. Change	F/T %Length Change	Chloride Permeability
Control Mix	572	0.0	9.3	0.366	2.00	6.30	4460	5302	672	682	54.01	0.179	0.2244	3943
Interval 2							4400	5373	655	680	54.95	0.405	0.2194	
							4470	5542	662	666	-	-	-	
					Average		4443	5406	663	676	54	0.2920	0.2219	3943
					Std. Deviation		38	123	9	9				

Mix Name	Cement (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/sack)	W/C Ratio	Slump (in)	Air (%)	7-Day Compress. Strength	28-Day Compress. Strength	7-Day Flexural Strength	28-Day Flexural Strength	F/T Durability Factor	F/T %Wt. Change	F/T %Length Change	Chloride Permeability
Control Mix	572	0.0	10.6	0.342	3.00	6.90	4260	5118	641	646	62.93	0.2088	0.3181	4859
Interval 3							4160	5214	628	662	56.56	0.2041	0.3050	
							4150	5012	624	637	50.21	0.2834	0.2844	
					Average		4190	5115	631	648	57	0.2321	0.3025	4859
					Std. Deviation		61	101	9	13	6	0.0445	0.0170	

Mix Name	Cement (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/sack)	W/C Ratio	Slump (in)	Air (%)	7-Day Compress. Strength	28-Day Compress. Strength	7-Day Flexural Strength	28-Day Flexural Strength	F/T Durability Factor	F/T %Wt. Change	F/T %Length Change	Chloride Permeability
Control Mix	572	0.0	10.6	0.342	2.00	6.30	4320	5151	626	656	66.58	0.2374	0.2706	4650
Interval 4							4200	5267	604	666	50.89	0.0363	0.3038	
							4280	5058	577	710	57.49	0.2464	0.2869	
					Average		4267	5159	602	677	58	0.1734	0.2871	4650
					Std. Deviation		61	105	25	29	8	0.1188	0.0166	

FIELD TESTING RESULTS
PCCP MIXES CONTAINING TYPE A WATER REDUCER AND DECREASED CEMENT CONTENT

Mix Name	Cement (lb/yd^3)	(oz ^3)	Air Agent (oz/sack)	W/C Ratio	Slump (in)	Air (%)	7-Day Strength	28-Day Compress. Strength	7-Day Flexural Strength	28-Day Flexural Strength	F/T Durability Factor	%Wt. Change	F/T %Length Change	Chloride Permeability
Water	546	20.0	3.5	0.368	0.75	5.80	4710	5667	699	696	34.42	0.1906	0.1969	2658
Reducer							4930	5905	655	702	33.44	0.4660	0.1875	
Interval 1							4740	6034	688	685	35.93	0.3055	0.1581	
					Average		4793	5869	681	694	35	.3207	0.0202	2658
					Std. Deviation		119	186	23	9	1	0.1383		

Mix Name	Cement (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/sack)	W/C Ratio	Slump (in)		7-Day Strength	28-Day Compress. Strength	7-Day Flexural Strength	28-Day Flexural Strength	F/T Durability Factor	F/T %Wt. Change	F/T %Length Change	Chloride Permeability
Water	546	20.0	3.5	0.368	1.50	7.50	4050	5358	593	674	49.9	0.4775	0.2244	2825
Reducer							4290	5233	637	653	50.08	0.4950	0.2144	
Interval 2							4240	5305	652	661	61.42	0.4918	0.1869	
					Average		4193	5299	627	663	54	0.4881	0.2086	2825
					Std. Deviation		127	63	31	11	7	0.0093	0.0194	

Mix Name	Cement (lb/yd^3)	WR (oz/yd^3)	Air Agent (oz/sack)	W/C Ratio	Slump (in)		7-Day Compress. Strength	28-Day Compress. Strength	7-Day Flexural Strength	28-Day Flexural Strength	F/T Durability	F/T %Wt. Change	F/T %Length Change	Chloride Permeability
Water	546	20.0	3.5	0.331	1.25	6.00	4650	5524	641	643	49.39	0.2094	0.3069	2474
Reducer							4730	5693	646	690	48.38	0.3164	0.3112	
Interval 3							4690	5380	600	706	42.54	0.2782	0.3181	
					Average		4690	5532	629	680	47	0.2680	0.3121	2474
					Std. Deviation		40	157	25	33	4	0.0542	0.0057	

Mix Name	Cement (lb/yd^3)	WR (oz ^3)	Air Agent (oz/sack)	W/C Ratio	Slump (in)	Air (%)	7-Day Strength	28-Day Compress. Strength	7-Day Flexural Strength	28-Day Flexural Strength	F/T Durability Factor	F/T %Wt. Change	F/T %Length Change	Chloride Per
Water	546	20.0	3.5	0.331	2.25	8.50	3870	4463	544	564	55.64	0.2428	0.2725	2768
Reducer							3530	4713	562	637	55.28	0.2147	0.2894	
Interval 4							3840	4659	509	598	60.8	0.1495	0.2344	
					Average		3747	4612	538	600	57	0.2023	0.2654	2768
					Std. Deviation		188	132	27	37	3	0.0479	0.0282	

APPENDIX D

Air Void Analysis Worksheets

Laboratory Air Void Analysis Worksheets

Without Water Reducer

- **Laboratory Mix 1 (Control)**
- **Laboratory Mix 2**
- **Laboratory Mix 5**
- **Laboratory Mix 8**

With Water Reducer

- **Laboratory Mix 3**
- **Laboratory Mix 4**
- **Laboratory Mix 6**
- **Laboratory Mix 7**
- **Laboratory Mix 9**
- **Laboratory Mix 10**

LABORATORY MIX 1

Summary of speciman M1A620.CHO on 06/05/2000
ASTM C-457 Procedure A

Length = 84.07783 | Percent Air = 4.819 | Average Air Void = 0.00495
Void/Paste Ratio = 0.091 | Percent Paste = 53.18 | Paste/Void Ratio = 11.04
Standard Dev of Air Void Sizes = 0.01399 | Voids Per Inch = 9.73
Spacing Factor = 0.0082 | Specific Surface = 807.56

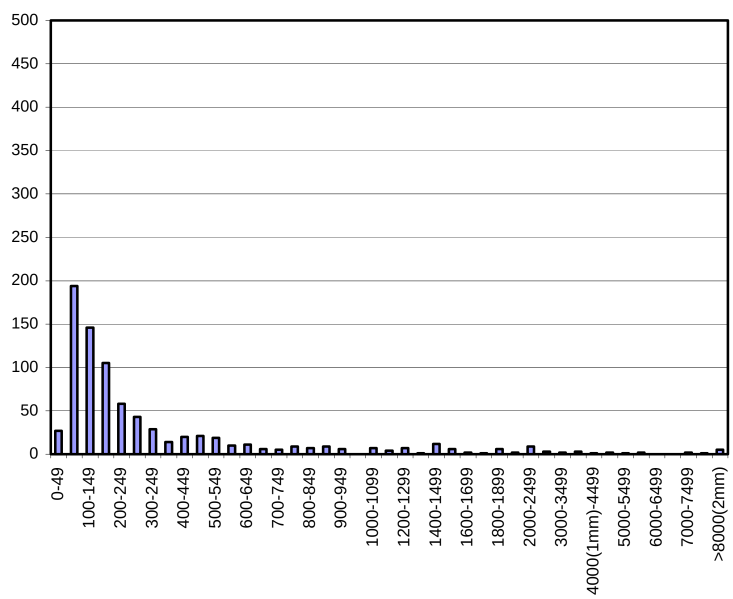
Specification Range: 0.004 - 0.008 | **Specification Range: 600 - 1100**

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	27	3.3	50	99 =	194	27.02	100	149 =	146	44.87
150	199 =	105	57.7	200	249 =	58	64.79	250	299 =	43	70.05
300	349 =	29	73.59	350	399 =	14	75.31	400	449 =	20	77.75
450	499 =	21	80.32	500	549 =	19	82.64	550	599 =	10	83.86
600	649 =	11	85.21	650	699 =	6	85.94	700	749 =	5	86.55
750	799 =	9	87.65	800	849 =	7	88.51	850	899 =	9	89.61
900	949 =	6	90.34	950	999 =	0	90.34	1000	1049 =	4	90.83
1050	1099 =	3	91.2	1100	1149 =	2	91.44	1150	1199 =	2	91.69
1200	1249 =	3	92.05	1250	1299 =	4	92.54	1300	1349 =	1	92.67
1350	1399 =	0	92.67	1400	149 =	4	93.15	1450	1499 =	8	94.13
1500	1549 =	3	94.5	1550	1599 =	3	94.87	1600	1649 =	1	94.99
1650	1699 =	1	95.11	1700	1749 =	1	95.23	1750	1499 =	0	95.23
1800	1849 =	3	95.6	1850	1899 =	3	95.97	1900	1949 =	2	96.21
1950	1999 =	0	96.21	2000	2499 =	9	97.31	2500	2999 =	3	97.68
3000	3499 =	2	97.92	3500	3999 =	3	98.29	4000	4499 =	1	98.41
4500	4999 =	2	98.66	5000	5499 =	1	98.78	5500	5999 =	2	99.02
6000	6499 =	0	99.02	6500	6999 =	0	99.02	7000	7499 =	2	99.27
7500	7999 =	1	99.39	**>=**	8000 =	5	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	4.819	9.061
<600	1.502	2.824
Tot Pct	83.86	
Tot No	686	
600-4000 (1 mm)	1.855	3.487
Tot Pct	14.43	
Tot No	118	
4000 (1 mm) - 8000 (2mm)	0.622	1.17
Tot Pct	1.1	
Tot No	9	
> 8000 (2mm)	0.84	1.579
Tot Pct	0	
Tot No	5	



LABORATORY MIX 2

Summary of speciman M3A600.CHO on 06/05/2000

ASTM C-457 Procedure A

Length = 85.23327 Percent Air = 5.177 Average Air Void = 0.00467

Void/Paste Ratio = 0.1 Percent Paste = 51.61 Paste/Void Ratio = 9.97

Standard Dev of Air Void Sizes = 0.01236 Voids Per Inch = 11.08

Spacing Factor = 0.0074 Specific Surface = 855.67

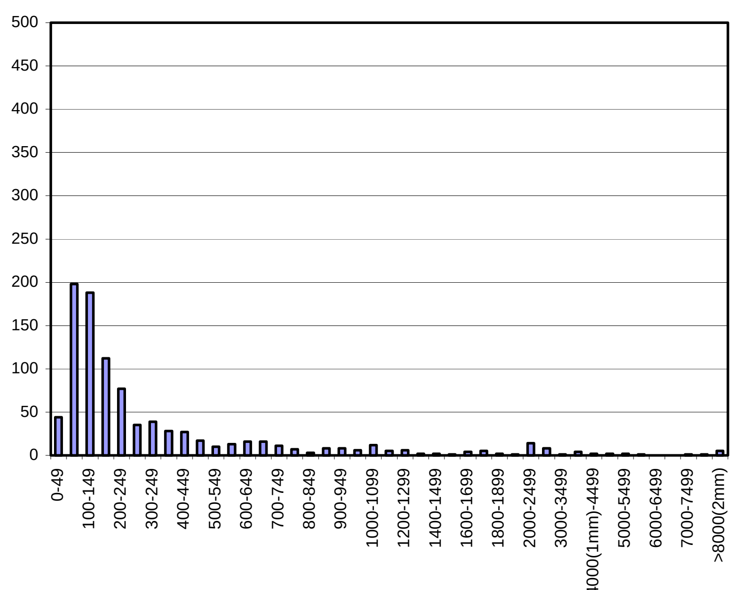
Specification Range: 0.004 - 0.008 **Specification Range: 600 - 1100**

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	44	4.66	50	99 =	198	25.64	100	149 =	188	45.55
150	199 =	112	57.42	200	249 =	77	65.57	250	299 =	35	69.28
300	349 =	39	73.41	350	399 =	28	76.38	400	449 =	27	79.24
450	499 =	17	81.04	500	549 =	10	82.1	550	599 =	13	83.47
600	649 =	16	85.17	650	699 =	16	86.86	700	749 =	11	88.03
750	799 =	7	88.77	800	849 =	3	89.09	850	899 =	8	89.94
900	949 =	8	90.78	950	999 =	6	91.42	1000	1049 =	7	92.16
1050	1099 =	5	92.69	1100	1149 =	3	93.01	1150	1199 =	2	93.22
1200	1249 =	2	93.43	1250	1299 =	4	93.86	1300	1349 =	0	93.86
1350	1399 =	2	94.07	1400	149 =	2	94.28	1450	1499 =	0	94.28
1500	1549 =	1	94.39	1550	1599 =	0	94.39	1600	1649 =	2	94.6
1650	1699 =	2	94.81	1700	1749 =	3	95.13	1750	1499 =	2	95.34
1800	1849 =	1	95.44	1850	1899 =	1	95.55	1900	1949 =	0	95.55
1950	1999 =	1	95.66	2000	2499 =	14	97.14	2500	2999 =	8	97.99
3000	3499 =	1	98.09	3500	3999 =	4	98.52	4000	4499 =	2	98.73
4500	4999 =	2	98.94	5000	5499 =	2	99.15	5500	5999 =	1	99.26
6000	6499 =	0	99.26	6500	6999 =	0	99.26	7000	7499 =	1	99.36
7500	7999 =	1	99.47	**>=**	8000 =	5	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	5.177	10.032
<600	1.664	3.225
Tot Pct	83.47	
Tot No	788	
600-4000 (1 mm)	2.117	4.103
Tot Pct	15.04	
Tot No	142	
4000 (1 mm) - 8000 (2mm)	0.581	1.126
Tot Pct	0.95	
Tot No	9	
> 8000 (2mm)	0.815	1.579
Tot Pct	0	
Tot No	5	



LABORATORY MIX 3

Summary of speciman M3B603.CHO on 06/05/2000
ASTM C-457 Procedure A

Length = 84.65063
Percent Air = 4.816
Average Air Void = 0.0043
Void/Paste Ratio = 0.086
Percent Paste = 56.03
Paste/Void Ratio = 11.63
Standard Dev of Air Void Sizes = 0.00887
Voids Per Inch = 11.21
Spacing Factor = 0.00728
Specific Surface = 931.11

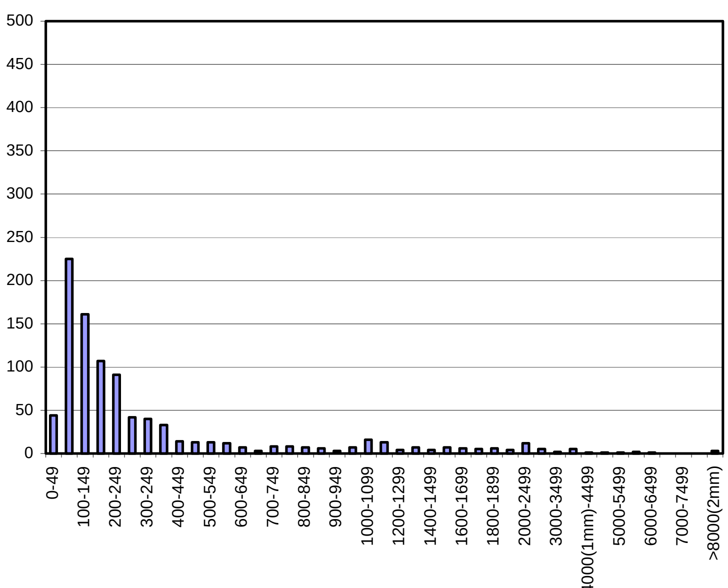
Specification Range: 0.004 - 0.008
Specification Range: 600 - 1100

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	44	4.64	50	99 =	225	28.35	100	149 =	161	45.31
150	199 =	107	56.59	200	249 =	91	66.17	250	299 =	42	70.6
300	349 =	40	74.82	350	399 =	33	78.29	400	449 =	14	79.77
450	499 =	13	81.14	500	549 =	13	82.51	550	599 =	12	83.77
600	649 =	7	84.51	650	699 =	3	84.83	700	749 =	8	85.67
750	799 =	8	86.51	800	849 =	7	87.25	850	899 =	6	87.88
900	949 =	3	88.2	950	999 =	7	88.94	1000	1049 =	8	89.78
1050	1099 =	8	90.62	1100	1149 =	5	91.15	1150	1199 =	8	91.99
1200	1249 =	4	92.41	1250	1299 =	0	92.41	1300	1349 =	5	92.94
1350	1399 =	2	93.15	1400	149 =	2	93.36	1450	1499 =	2	93.57
1500	1549 =	3	93.89	1550	1599 =	4	94.31	1600	1649 =	4	94.73
1650	1699 =	2	94.94	1700	1749 =	2	95.15	1750	1499 =	3	95.47
1800	1849 =	3	95.79	1850	1899 =	3	96.1	1900	1949 =	2	96.31
1950	1999 =	2	96.52	2000	2499 =	12	97.79	2500	2999 =	5	98.31
3000	3499 =	2	98.52	3500	3999 =	5	99.05	4000	4499 =	1	99.16
4500	4999 =	1	99.26	5000	5499 =	1	99.37	5500	5999 =	2	99.58
6000	6499 =	1	99.68	6500	6999 =	0	99.68	7000	7499 =	0	99.68
7500	7999 =	0	99.68	**>=**	8000 =	3	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	4.816	8.595
<600	1.644	2.933
Tot Pct	83.77	
Tot No	795	
600-4000 (1 mm)	2.425	4.328
Tot Pct	15.28	
Tot No	145	
4000 (1 mm) - 8000 (2mm)	0.379	0.676
Tot Pct	0.63	
Tot No	6	
> 8000 (2mm)	0.369	0.658
Tot Pct	0	
Tot No	3	



LABORATORY MIX 4

Summary of speciman M3A605.CHO on 06/05/2000

ASTM C-457 Procedure A

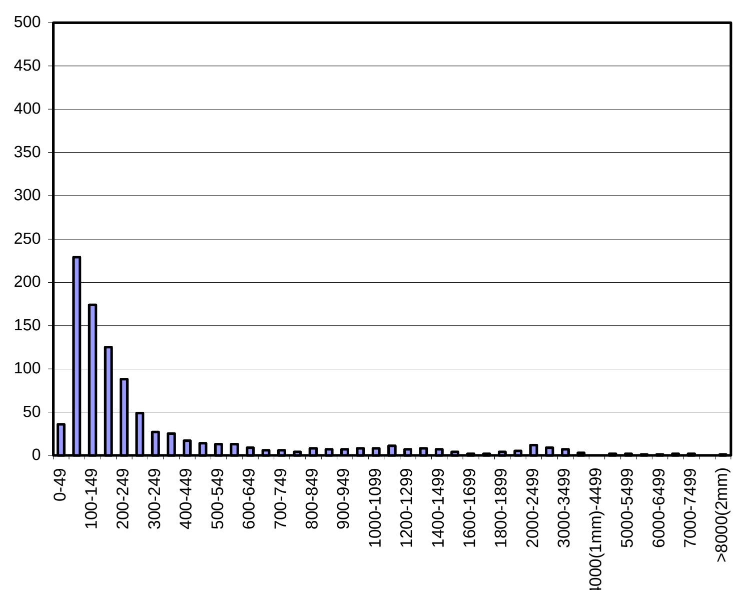
Length = 84.87434	Percent Air = 4.938		Average Air Void = 0.00434
Void/Paste Ratio = 0.098	Percent Paste = 50.3		Paste/Void Ratio = 10.19
Standard Dev of Air Void Sizes = 0.00853		Voids Per Inch = 11.37	
Spacing Factor = 0.00694		Specific Surface = 921.03	
Specification Range: 0.004 - 0.008		**Specification Range: 600 - 1100**	

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	36	3.73	50	99 =	229	27.46	100	149 =	174	45.49
150	199 =	125	58.45	200	249 =	88	67.56	250	299 =	49	72.64
300	349 =	27	75.44	350	399 =	25	78.03	400	449 =	17	79.79
450	499 =	14	81.24	500	549 =	13	82.59	550	599 =	13	83.94
600	649 =	9	84.87	650	699 =	6	85.49	700	749 =	6	86.11
750	799 =	4	86.53	800	849 =	8	87.36	850	899 =	7	88.08
900	949 =	7	88.81	950	999 =	8	89.64	1000	1049 =	5	90.16
1050	1099 =	3	90.47	1100	1149 =	5	90.98	1150	1199 =	6	91.61
1200	1249 =	3	91.92	1250	1299 =	4	92.33	1300	1349 =	5	92.85
1350	1399 =	3	93.16	1400	149 =	3	93.47	1450	1499 =	4	93.89
1500	1549 =	2	94.09	1550	1599 =	2	94.3	1600	1649 =	0	94.3
1650	1699 =	2	94.51	1700	1749 =	1	94.61	1750	1499 =	1	94.72
1800	1849 =	2	94.92	1850	1899 =	2	95.13	1900	1949 =	2	95.34
1950	1999 =	3	95.65	2000	2499 =	12	96.89	2500	2999 =	9	97.82
3000	3499 =	7	98.55	3500	3999 =	3	98.86	4000	4499 =	0	98.86
4500	4999 =	2	99.07	5000	5499 =	2	99.27	5500	5999 =	1	99.38
6000	6499 =	1	99.48	6500	6999 =	2	99.69	7000	7499 =	2	99.9
7500	7999 =	0	99.9	**>=**	8000 =	1	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	4.938	9.817
<600	1.661	3.303
Tot Pct	83.94	
Tot No	810	
600-4000 (1 mm)	2.463	4.897
Tot Pct	14.92	
Tot No	144	
4000 (1 mm) - 8000 (2mm)	0.698	1.387
Tot Pct	1.04	
Tot No	10	
> 8000 (2mm)	0.116	0.23
Tot Pct	0	
Tot No	1	



LABORATORY MIX 5

Summary of speciman M2B580.CHO on 06/05/2000
ASTM C-457 Procedure A

Length = 84.96111 | Percent Air = 4.448 | Average Air Void = 0.00466
Void/Paste Ratio = 0.083 | Percent Paste = 53.64 | Paste/Void Ratio = 12.06
Standard Dev of Air Void Sizes = 0.01041 | Voids Per Inch = 9.55
Spacing Factor = 0.00803 | Specific Surface = 858.39

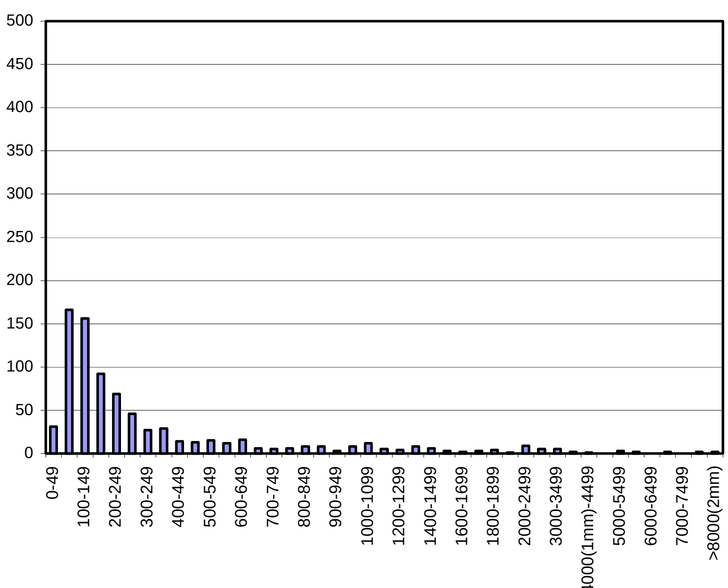
Specification Range: 0.004 - 0.008 | **Specification Range: 600 - 1100**

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	31	3.82	50	99 =	166	24.29	100	149 =	156	43.53
150	199 =	92	54.87	200	249 =	69	63.38	250	299 =	46	69.05
300	349 =	27	72.38	350	399 =	29	75.96	400	449 =	14	77.68
450	499 =	13	79.28	500	549 =	15	81.13	550	599 =	12	82.61
600	649 =	16	84.59	650	699 =	6	85.33	700	749 =	5	85.94
750	799 =	6	86.68	800	849 =	8	87.67	850	899 =	8	88.66
900	949 =	3	89.03	950	999 =	8	90.01	1000	1049 =	2	90.26
1050	1099 =	10	91.49	1100	1149 =	4	91.99	1150	1199 =	1	92.11
1200	1249 =	0	92.11	1250	1299 =	4	92.6	1300	1349 =	5	93.22
1350	1399 =	3	93.59	1400	149 =	3	93.96	1450	1499 =	3	94.33
1500	1549 =	2	94.57	1550	1599 =	1	94.7	1600	1649 =	1	94.82
1650	1699 =	1	94.94	1700	1749 =	1	95.07	1750	1499 =	2	95.31
1800	1849 =	1	95.44	1850	1899 =	3	95.81	1900	1949 =	0	95.81
1950	1999 =	1	95.93	2000	2499 =	9	97.04	2500	2999 =	5	97.66
3000	3499 =	5	98.27	3500	3999 =	2	98.52	4000	4499 =	1	98.64
4500	4999 =	0	98.64	5000	5499 =	3	99.01	5500	5999 =	2	99.26
6000	6499 =	0	99.26	6500	6999 =	2	99.51	7000	7499 =	0	99.51
7500	7999 =	2	99.75	**>=**	8000 =	2	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	4.448	8.293
<600	1.447	2.698
Tot Pct	82.61	
Tot No	670	
600-4000 (1 mm)	1.978	3.688
Tot Pct	15.91	
Tot No	129	
4000 (1 mm) - 8000 (2mm)	0.705	1.315
Tot Pct	1.23	
Tot No	10	
> 8000 (2mm)	0.318	0.592
Tot Pct	0	
Tot No	2	



LABORATORY MIX 6

Summary of speciman M1A583.CHO on 06/05/2000
ASTM C-457 Procedure A

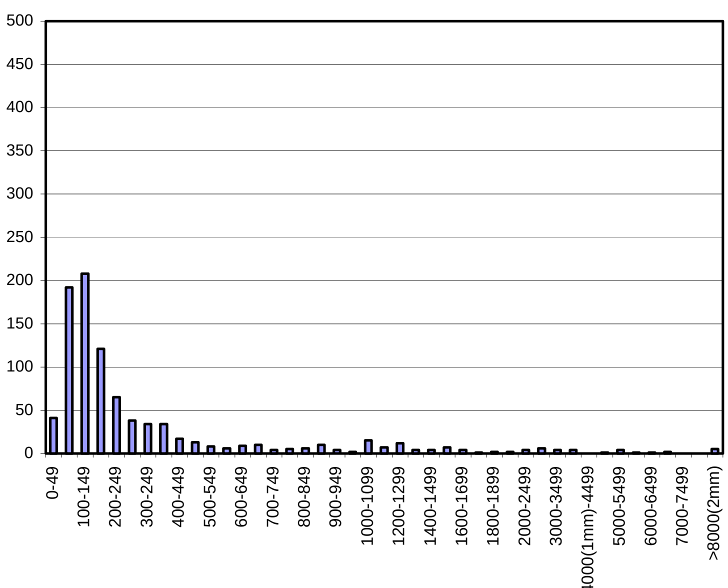
Length = 84.35411	Percent Air = 4.722	Average Air Void = 0.00434
Void/Paste Ratio = 0.086	Percent Paste = 55.2	Paste/Void Ratio = 11.69
Standard Dev of Air Void Sizes = 0.00999		Voids Per Inch = 10.87
Spacing Factor = 0.00738		Specific Surface = 920.82
Specification Range: 0.004 - 0.008		**Specification Range: 600 - 1100**

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	41	4.47	50	99 =	192	25.41	100	149 =	208	48.09
150	199 =	121	61.29	200	249 =	65	68.38	250	299 =	38	72.52
300	349 =	34	76.23	350	399 =	34	79.93	400	449 =	17	81.79
450	499 =	13	83.21	500	549 =	8	84.08	550	599 =	6	84.73
600	649 =	9	85.71	650	699 =	10	86.8	700	749 =	4	87.24
750	799 =	5	87.79	800	849 =	6	88.44	850	899 =	10	89.53
900	949 =	4	89.97	950	999 =	2	90.19	1000	1049 =	10	91.28
1050	1099 =	5	91.82	1100	1149 =	3	92.15	1150	1199 =	4	92.58
1200	1249 =	9	93.57	1250	1299 =	3	93.89	1300	1349 =	1	94
1350	1399 =	3	94.33	1400	149 =	4	94.77	1450	1499 =	0	94.77
1500	1549 =	3	95.09	1550	1599 =	4	95.53	1600	1649 =	2	95.75
1650	1699 =	2	95.97	1700	1749 =	0	95.97	1750	1499 =	1	96.07
1800	1849 =	2	96.29	1850	1899 =	0	96.29	1900	1949 =	2	96.51
1950	1999 =	0	96.51	2000	2499 =	4	96.95	2500	2999 =	6	97.6
3000	3499 =	4	98.04	3500	3999 =	4	98.47	4000	4499 =	0	98.47
4500	4999 =	1	98.58	5000	5499 =	4	99.02	5500	5999 =	1	99.13
6000	6499 =	1	99.24	6500	6999 =	2	99.45	7000	7499 =	0	99.45
7500	7999 =	0	99.45	**>=**	8000 =	5	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	4.722	8.555
<600	1.57	2.844
Tot Pct	84.73	
Tot No	777	
600-4000 (1 mm)	1.985	3.595
Tot Pct	13.74	
Tot No	126	
4000 (1 mm) - 8000 (2mm)	0.606	1.098
Tot Pct	0.98	
Tot No	9	
> 8000 (2mm)	0.562	1.017
Tot Pct	0	
Tot No	5	



LABORATORY MIX 7

Summary of speciman M1A585.CHO on 06/05/2000
ASTM C-457 Procedure A

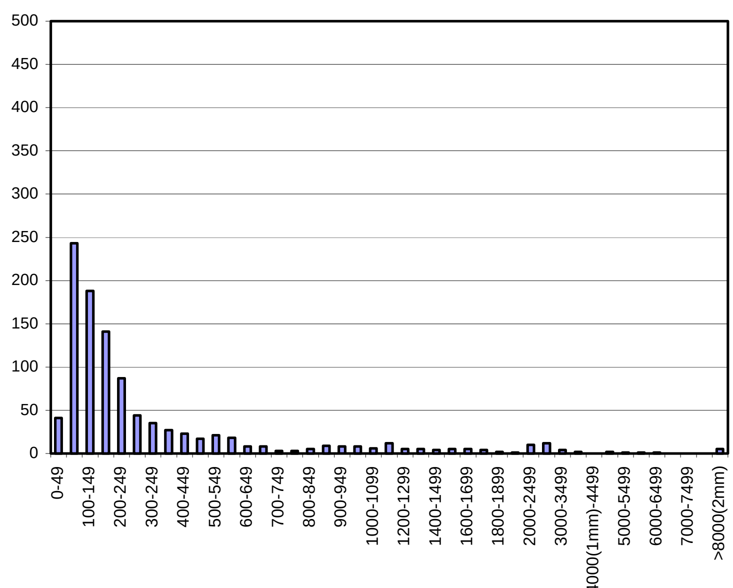
Length =	83.81619	Percent Air =	5.129	Average Air Void =	0.0042
Void/Paste Ratio =	0.094	Percent Paste =	54.52	Paste/Void Ratio =	10.63
Standard Dev of Air Void Sizes =	0.01036			Voids Per Inch =	12.22
Spacing Factor =	0.00684			Specific Surface =	952.87
Specification Range: 0.004 - 0.008				**Specification Range: 600 - 1100**	

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	41	4	50	99 =	243	27.73	100	149 =	188	46.09
150	199 =	141	59.86	200	249 =	87	68.36	250	299 =	44	72.66
300	349 =	35	76.07	350	399 =	27	78.71	400	449 =	23	80.96
450	499 =	17	82.62	500	549 =	21	84.67	550	599 =	18	86.43
600	649 =	8	87.21	650	699 =	8	87.99	700	749 =	3	88.28
750	799 =	3	88.57	800	849 =	5	89.06	850	899 =	9	89.94
900	949 =	8	90.72	950	999 =	8	91.5	1000	1049 =	3	91.8
1050	1099 =	3	92.09	1100	1149 =	4	92.48	1150	1199 =	8	93.26
1200	1249 =	5	93.75	1250	1299 =	0	93.75	1300	1349 =	2	93.95
1350	1399 =	3	94.24	1400	149 =	0	94.24	1450	1499 =	4	94.63
1500	1549 =	1	94.73	1550	1599 =	4	95.12	1600	1649 =	4	95.51
1650	1699 =	1	95.61	1700	1749 =	2	95.8	1750	1499 =	2	96
1800	1849 =	2	96.19	1850	1899 =	0	96.19	1900	1949 =	1	96.29
1950	1999 =	0	96.29	2000	2499 =	10	97.27	2500	2999 =	12	98.44
3000	3499 =	4	98.83	3500	3999 =	2	99.02	4000	4499 =	0	99.02
4500	4999 =	2	99.22	5000	5499 =	1	99.32	5500	5999 =	1	99.41
6000	6499 =	1	99.51	6500	6999 =	0	99.51	7000	7499 =	0	99.51
7500	7999 =	0	99.51	**>=**	8000 =	5	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	5.129	9.406
<600	1.899	3.484
Tot Pct	86.43	
Tot No	885	
600-4000 (1 mm)	2.204	4.043
Tot Pct	12.6	
Tot No	129	
4000 (1 mm) - 8000 (2mm)	0.318	0.584
Tot Pct	0.49	
Tot No	5	
> 8000 (2mm)	0.706	1.296
Tot Pct	0	
Tot No	5	



LABORATORY MIX 8

Summary of speciman M3A560.CHO on 06/05/2000
ASTM C-457 Procedure A

Length = 84.26158 | Percent Air = 4.415 | Average Air Void = 0.00454
Void/Paste Ratio = 0.085 | Percent Paste = 51.76 | Paste/Void Ratio = 11.72
Standard Dev of Air Void Sizes = 0.01047 | Voids Per Inch = 9.73
Spacing Factor = 0.00772 | Specific Surface = 881.63

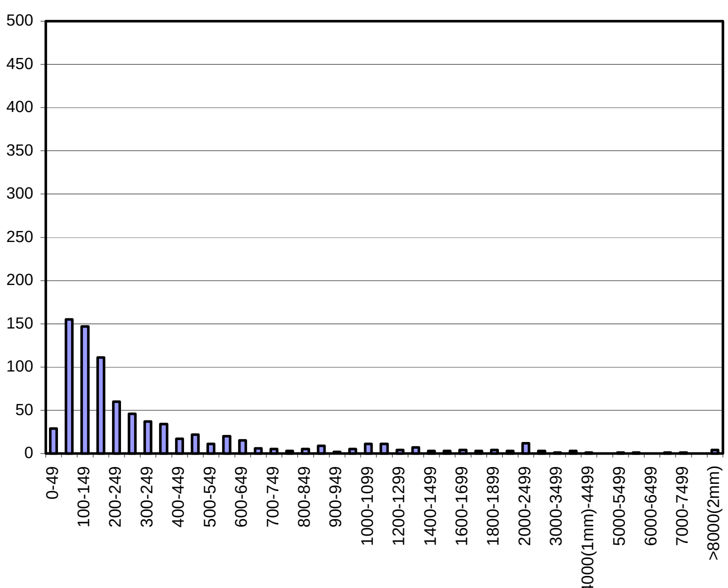
Specification Range: 0.004 - 0.008 | **Specification Range: 600 - 1100**

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	29	3.54	50	99 =	155	22.44	100	149 =	147	40.37
150	199 =	111	53.9	200	249 =	60	61.22	250	299 =	46	66.83
300	349 =	37	71.34	350	399 =	34	75.49	400	449 =	17	77.56
450	499 =	22	80.24	500	549 =	11	81.59	550	599 =	20	84.02
600	649 =	15	85.85	650	699 =	6	86.59	700	749 =	5	87.2
750	799 =	3	87.56	800	849 =	5	88.17	850	899 =	9	89.27
900	949 =	2	89.51	950	999 =	5	90.12	1000	1049 =	5	90.73
1050	1099 =	6	91.46	1100	1149 =	3	91.83	1150	1199 =	8	92.8
1200	1249 =	3	93.17	1250	1299 =	1	93.29	1300	1349 =	4	93.78
1350	1399 =	3	94.15	1400	149 =	1	94.27	1450	1499 =	2	94.51
1500	1549 =	2	94.76	1550	1599 =	1	94.88	1600	1649 =	3	95.24
1650	1699 =	1	95.37	1700	1749 =	3	95.73	1750	1499 =	0	95.73
1800	1849 =	3	96.1	1850	1899 =	1	96.22	1900	1949 =	1	96.34
1950	1999 =	2	96.59	2000	2499 =	12	98.05	2500	2999 =	3	98.41
3000	3499 =	1	98.54	3500	3999 =	3	98.9	4000	4499 =	1	99.02
4500	4999 =	0	99.02	5000	5499 =	1	99.15	5500	5999 =	1	99.27
6000	6499 =	0	99.27	6500	6999 =	1	99.39	7000	7499 =	1	99.51
7500	7999 =	0	99.51	**>=**	8000 =	4	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	4.415	8.53
<600	1.614	3.119
Tot Pct	84.02	
Tot No	689	
600-4000 (1 mm)	1.899	3.669
Tot Pct	14.88	
Tot No	122	
4000 (1 mm) - 8000 (2mm)	0.355	0.685
Tot Pct	0.61	
Tot No	5	
> 8000 (2mm)	0.547	1.057
Tot Pct	0	
Tot No	4	



LABORATORY MIX 9

Summary of speciman M3B563.CHO on 06/05/2000
ASTM C-457 Procedure A

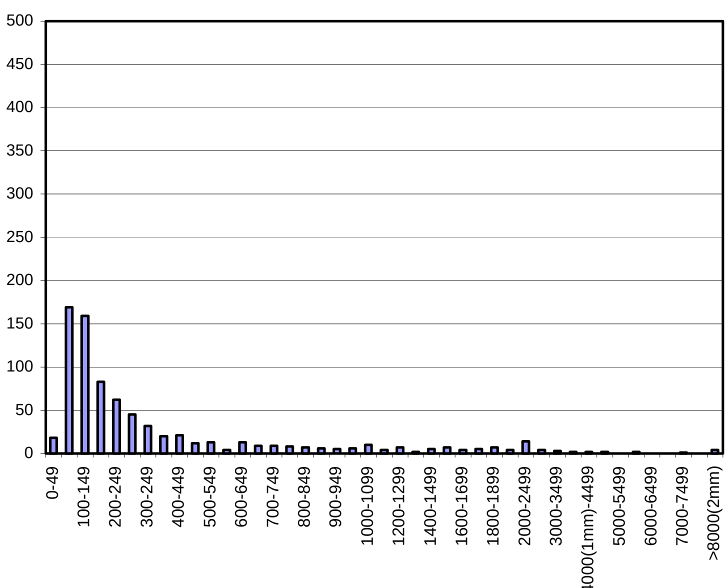
Length = 84.30949	Percent Air = 4.59	Average Air Void = 0.0049
Void/Paste Ratio = 0.091	Percent Paste = 50.57	Paste/Void Ratio = 11.02
Standard Dev of Air Void Sizes = 0.01131		Voids Per Inch = 9.37
Spacing Factor = 0.00811		Specific Surface = 816.65
Specification Range: 0.004 - 0.008		**Specification Range: 600 - 1100**

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	18	2.28	50	99 =	169	23.67	100	149 =	159	43.8
150	199 =	83	54.3	200	249 =	62	62.15	250	299 =	45	67.85
300	349 =	32	71.9	350	399 =	20	74.43	400	449 =	21	77.09
450	499 =	12	78.61	500	549 =	13	80.25	550	599 =	4	80.76
600	649 =	13	82.41	650	699 =	9	83.54	700	749 =	9	84.68
750	799 =	8	85.7	800	849 =	7	86.58	850	899 =	6	87.34
900	949 =	5	87.97	950	999 =	6	88.73	1000	1049 =	7	89.62
1050	1099 =	3	90	1100	1149 =	1	90.13	1150	1199 =	3	90.51
1200	1249 =	5	91.14	1250	1299 =	2	91.39	1300	1349 =	0	91.39
1350	1399 =	2	91.65	1400	149 =	4	92.15	1450	1499 =	1	92.28
1500	1549 =	2	92.53	1550	1599 =	5	93.16	1600	1649 =	2	93.42
1650	1699 =	2	93.67	1700	1749 =	2	93.92	1750	1499 =	3	94.3
1800	1849 =	3	94.68	1850	1899 =	4	95.19	1900	1949 =	2	95.44
1950	1999 =	2	95.7	2000	2499 =	14	97.47	2500	2999 =	4	97.97
3000	3499 =	3	98.35	3500	3999 =	2	98.61	4000	4499 =	2	98.86
4500	4999 =	2	99.11	5000	5499 =	0	99.11	5500	5999 =	2	99.37
6000	6499 =	0	99.37	6500	6999 =	0	99.37	7000	7499 =	1	99.49
7500	7999 =	0	99.49	**>=**	8000 =	4	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	4.59	9.075
<600	1.366	2.7
Tot Pct	80.76	
Tot No	638	
600-4000 (1 mm)	2.239	4.426
Tot Pct	17.85	
Tot No	141	
4000 (1 mm) - 8000 (2mm)	0.435	0.86
Tot Pct	0.89	
Tot No	7	
> 8000 (2mm)	0.55	1.088
Tot Pct	0	
Tot No	4	



LABORATORY MIX 10

Summary of speciman M2A565.CHO on 06/05/2000
ASTM C-457 Procedure A

Length = 84.88694 | Percent Air = 4.352 | Average Air Void = 0.00394
Void/Paste Ratio = 0.079 | Percent Paste = 55.15 | Paste/Void Ratio = 12.67
Standard Dev of Air Void Sizes = 0.0077 | Voids Per Inch = 11.04
Spacing Factor = 0.00694 | Specific Surface = 1014.54

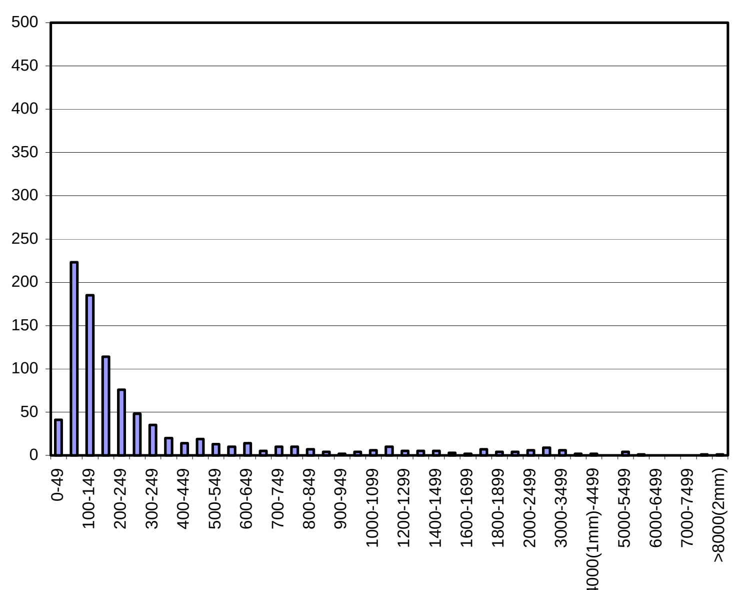
Specification Range: 0.004 - 0.008 | **Specification Range: 600 - 1100**

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	41	4.38	50	99 =	223	28.18	100	149 =	185	47.92
150	199 =	114	60.09	200	249 =	76	68.2	250	299 =	48	73.32
300	349 =	35	77.05	350	399 =	20	79.19	400	449 =	14	80.68
450	499 =	19	82.71	500	549 =	13	84.1	550	599 =	10	85.17
600	649 =	14	86.66	650	699 =	5	87.19	700	749 =	10	88.26
750	799 =	10	89.33	800	849 =	7	90.07	850	899 =	4	90.5
900	949 =	2	90.72	950	999 =	4	91.14	1000	1049 =	4	91.57
1050	1099 =	2	91.78	1100	1149 =	6	92.42	1150	1199 =	4	92.85
1200	1249 =	4	93.28	1250	1299 =	1	93.38	1300	1349 =	3	93.7
1350	1399 =	2	93.92	1400	149 =	2	94.13	1450	1499 =	3	94.45
1500	1549 =	2	94.66	1550	1599 =	1	94.77	1600	1649 =	1	94.88
1650	1699 =	1	94.98	1700	1749 =	6	95.62	1750	1499 =	1	95.73
1800	1849 =	2	95.94	1850	1899 =	2	96.16	1900	1949 =	2	96.37
1950	1999 =	2	96.58	2000	2499 =	6	97.23	2500	2999 =	9	98.19
3000	3499 =	6	98.83	3500	3999 =	2	99.04	4000	4499 =	2	99.25
4500	4999 =	0	99.25	5000	5499 =	4	99.68	5500	5999 =	1	99.79
6000	6499 =	0	99.79	6500	6999 =	0	99.79	7000	7499 =	0	99.79
7500	7999 =	1	99.89	**>=**	8000 =	1	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	4.352	7.892
<600	1.61	2.919
Tot Pct	85.17	
Tot No	798	
600-4000 (1 mm)	2.119	3.843
Tot Pct	13.87	
Tot No	130	
4000 (1 mm) - 8000 (2mm)	0.507	0.919
Tot Pct	0.85	
Tot No	8	
> 8000 (2mm)	0.116	0.211
Tot Pct	0	
Tot No	1	



Field Air Void Analysis Worksheets

Without Water Reducer	With Water Reducer
Con 1a	WR 1a
Con 1b	WR 1b
Con 2a	WR 2a
Con 2b	WR 2b

Summary of speciman CON1A.CHO on 02/15/2001
ASTM C-457 Procedure A

Length = 83.74313 | Percent Air = 4.829 | Average Air Void = 0.00347
Void/Paste Ratio = 0.097 | Percent Paste = 49.86 | Paste/Void Ratio = 10.32
Standard Dev of Air Void Sizes = 0.0124 | Voids Per Inch = 13.9
Spacing Factor = 0.00559 | Specific Surface = 1151.25

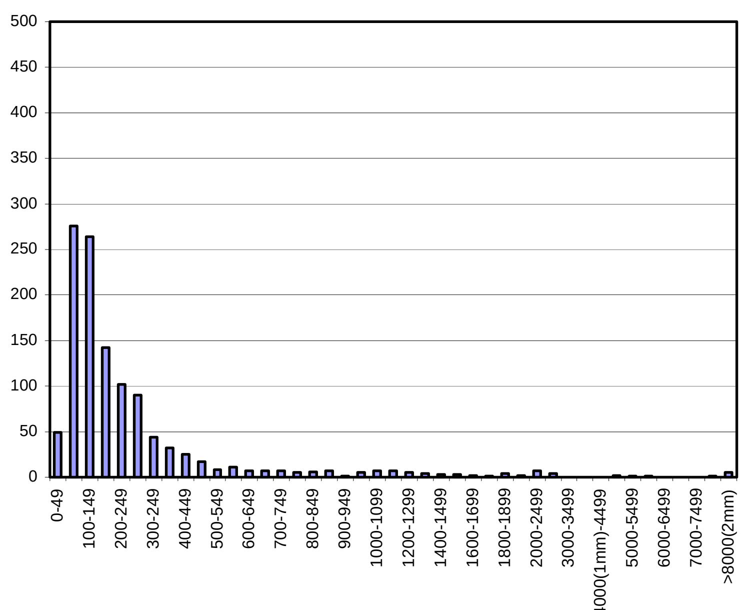
Specification Range: 0.004 - 0.008 | **Specification Range: 600 - 1100**

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	49	4.21	50	99 =	276	27.92	100	149 =	264	50.6
150	199 =	142	62.8	200	249 =	102	71.56	250	299 =	90	79.3
300	349 =	44	83.08	350	399 =	32	85.82	400	449 =	25	87.97
450	499 =	17	89.43	500	549 =	8	90.12	550	599 =	11	91.07
600	649 =	7	91.67	650	699 =	7	92.27	700	749 =	7	92.87
750	799 =	5	93.3	800	849 =	6	93.81	850	899 =	7	94.42
900	949 =	1	94.5	950	999 =	5	94.93	1000	1049 =	4	95.27
1050	1099 =	3	95.53	1100	1149 =	5	95.96	1150	1199 =	2	96.13
1200	1249 =	4	96.48	1250	1299 =	1	96.56	1300	1349 =	2	96.74
1350	1399 =	2	96.91	1400	149 =	2	97.08	1450	1499 =	1	97.16
1500	1549 =	3	97.42	1550	1599 =	0	97.42	1600	1649 =	1	97.51
1650	1699 =	1	97.59	1700	1749 =	1	97.68	1750	1499 =	0	97.68
1800	1849 =	2	97.85	1850	1899 =	2	98.02	1900	1949 =	1	98.11
1950	1999 =	1	98.2	2000	2499 =	7	98.8	2500	2999 =	4	99.14
3000	3499 =	0	99.14	3500	3999 =	0	99.14	4000	4499 =	0	99.14
4500	4999 =	2	99.31	5000	5499 =	1	99.4	5500	5999 =	1	99.48
6000	6499 =	0	99.48	6500	6999 =	0	99.48	7000	7499 =	0	99.48
7500	7999 =	1	99.57	**>=**	8000 =	5	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	4.829	9.687
<600	2.19	4.392
Tot Pct	91.07	
Tot No	1060	
600-4000 (1 mm)	1.355	2.718
Tot Pct	8.08	
Tot No	94	
4000 (1 mm) - 8000 (2mm)	0.34	0.683
Tot Pct	0.43	
Tot No	5	
> 8000 (2mm)	0.945	1.895
Tot Pct	0	
Tot No	5	



Summary of speciman CON1B.CHO on 02/15/2001
ASTM C-457 Procedure A

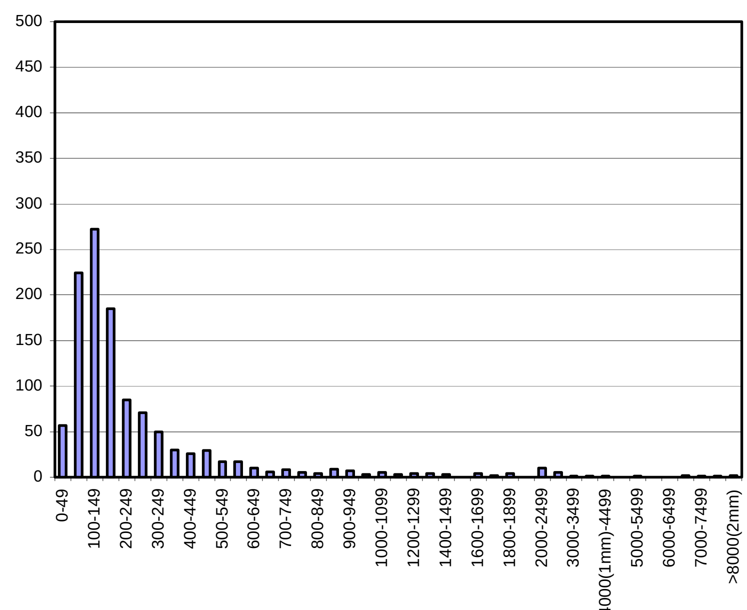
Length = 83.45643 Percent Air = 4.549 Average Air Void = 0.00325
Void/Paste Ratio = 0.087 Percent Paste = 52.51 Paste/Void Ratio = 11.54
Standard Dev of Air Void Sizes = 0.00753 Voids Per Inch = 14.01
Spacing Factor = 0.00549 Specific Surface = 1231.63
Specification Range: 0.004 - 0.008 **Specification Range: 600 - 1100**

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	57	4.88	50	99 =	224	24.04	100	149 =	272	47.31
150	199 =	185	63.13	200	249 =	85	70.4	250	299 =	71	76.48
300	349 =	50	80.75	350	399 =	30	83.32	400	449 =	26	85.54
450	499 =	29	88.02	500	549 =	17	89.48	550	599 =	17	90.93
600	649 =	10	91.79	650	699 =	6	92.3	700	749 =	8	92.99
750	799 =	5	93.41	800	849 =	4	93.76	850	899 =	9	94.53
900	949 =	7	95.12	950	999 =	3	95.38	1000	1049 =	2	95.55
1050	1099 =	3	95.81	1100	1149 =	2	95.98	1150	1199 =	1	96.07
1200	1249 =	2	96.24	1250	1299 =	2	96.41	1300	1349 =	3	96.66
1350	1399 =	1	96.75	1400	149 =	2	96.92	1450	1499 =	1	97.01
1500	1549 =	0	97.01	1550	1599 =	0	97.01	1600	1649 =	2	97.18
1650	1699 =	2	97.35	1700	1749 =	0	97.35	1750	1499 =	2	97.52
1800	1849 =	4	97.86	1850	1899 =	0	97.86	1900	1949 =	0	97.86
1950	1999 =	0	97.86	2000	2499 =	10	98.72	2500	2999 =	5	99.14
3000	3499 =	1	99.23	3500	3999 =	1	99.32	4000	4499 =	1	99.4
4500	4999 =	0	99.4	5000	5499 =	1	99.49	5500	5999 =	0	99.49
6000	6499 =	0	99.49	6500	6999 =	2	99.66	7000	7499 =	1	99.74
7500	7999 =	1	99.83	**>=**	8000 =	2	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	4.549	8.663
<600	2.323	4.423
Tot Pct	90.93	
Tot No	1063	
600-4000 (1 mm)	1.489	2.835
Tot Pct	8.38	
Tot No	98	
4000 (1 mm) - 8000 (2mm)	0.454	0.865
Tot Pct	0.51	
Tot No	6	
> 8000 (2mm)	0.284	0.54
Tot Pct	0	
Tot No	2	



Summary of speciman CON2A.CHO on 02/15/2001
ASTM C-457 Procedure A

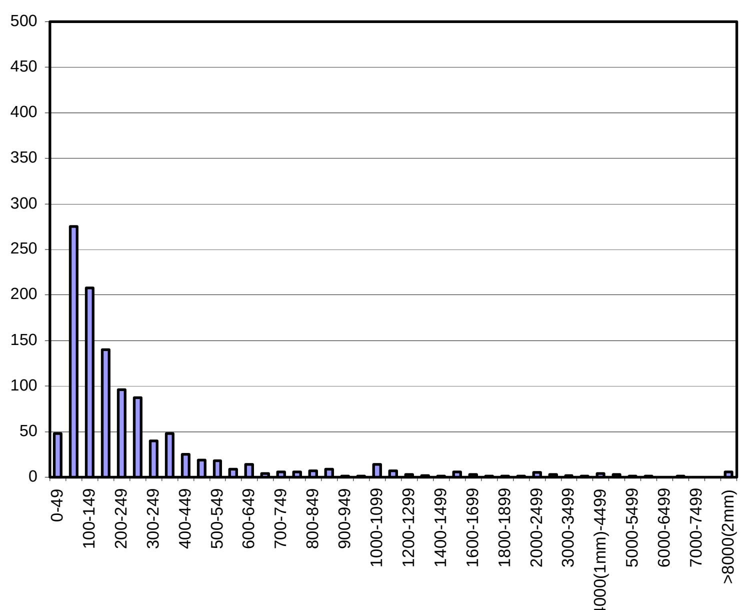
Length = 84.79771	Percent Air = 5.327	Average Air Void = 0.00401
Void/Paste Ratio = 0.104	Percent Paste = 51.06	Paste/Void Ratio = 9.58
Standard Dev of Air Void Sizes = 0.01552		Voids Per Inch = 13.29
Spacing Factor = 0.00623		Specific Surface = 997.91
Specification Range: 0.004 - 0.008		**Specification Range: 600 - 1100**

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	48	4.26	50	99 =	275	28.66	100	149 =	208	47.12
150	199 =	140	59.54	200	249 =	96	68.06	250	299 =	87	75.78
300	349 =	40	79.33	350	399 =	48	83.58	400	449 =	25	85.8
450	499 =	19	87.49	500	549 =	18	89.09	550	599 =	9	89.88
600	649 =	14	91.13	650	699 =	4	91.48	700	749 =	6	92.01
750	799 =	6	92.55	800	849 =	7	93.17	850	899 =	9	93.97
900	949 =	1	94.06	950	999 =	1	94.14	1000	1049 =	6	94.68
1050	1099 =	8	95.39	1100	1149 =	4	95.74	1150	1199 =	3	96.01
1200	1249 =	2	96.18	1250	1299 =	1	96.27	1300	1349 =	0	96.27
1350	1399 =	2	96.45	1400	149 =	1	96.54	1450	1499 =	0	96.54
1500	1549 =	4	96.89	1550	1599 =	2	97.07	1600	1649 =	2	97.25
1650	1699 =	1	97.34	1700	1749 =	1	97.43	1750	1499 =	0	97.43
1800	1849 =	0	97.43	1850	1899 =	1	97.52	1900	1949 =	0	97.52
1950	1999 =	1	97.6	2000	2499 =	5	98.05	2500	2999 =	3	98.31
3000	3499 =	2	98.49	3500	3999 =	1	98.58	4000	4499 =	4	98.94
4500	4999 =	3	99.2	5000	5499 =	1	99.29	5500	5999 =	1	99.38
6000	6499 =	0	99.38	6500	6999 =	1	99.47	7000	7499 =	0	99.47
7500	7999 =	0	99.47	**>=**	8000 =	6	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	5.327	10.434
<600	2.155	4.22
Tot Pct	89.88	
Tot No	1013	
600-4000 (1 mm)	1.363	2.67
Tot Pct	8.7	
Tot No	98	
4000 (1 mm) - 8000 (2mm)	0.578	1.133
Tot Pct	0.89	
Tot No	10	
> 8000 (2mm)	1.231	2.411
Tot Pct	0	
Tot No	6	



Summary of speciman CON2B.CHO on 02/15/2001
ASTM C-457 Procedure A

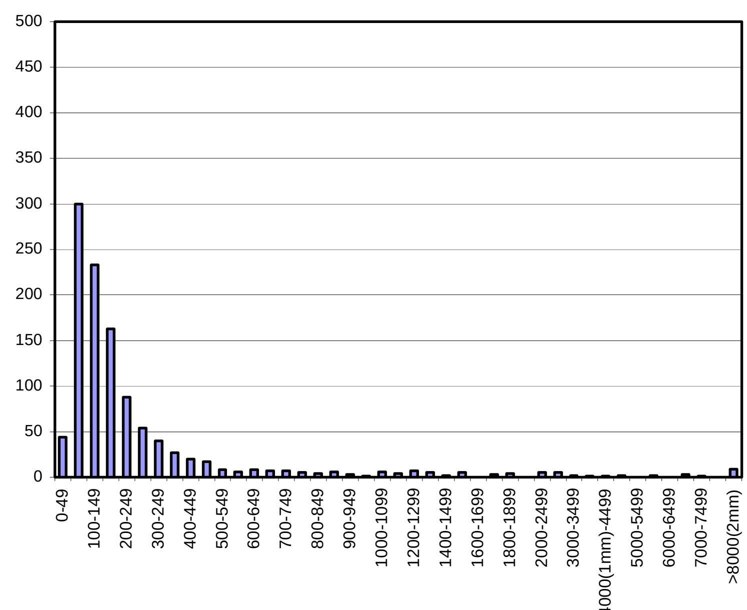
Length = 83.4363 Percent Air = 6.499 Average Air Void = 0.00489
Void/Paste Ratio = 0.119 Percent Paste = 54.65 Paste/Void Ratio = 8.41
Standard Dev of Air Void Sizes = 0.02596 Voids Per Inch = 13.28
Spacing Factor = 0.00718 Specific Surface = 817.38
Specification Range: 0.004 - 0.008 **Specification Range: 600 - 1100**

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	44	3.97	50	99 =	300	31.05	100	149 =	233	52.08
150	199 =	163	66.79	200	249 =	88	74.73	250	299 =	54	79.6
300	349 =	40	83.21	350	399 =	27	85.65	400	449 =	20	87.45
450	499 =	17	88.99	500	549 =	8	89.71	550	599 =	6	90.25
600	649 =	8	90.97	650	699 =	7	91.61	700	749 =	7	92.24
750	799 =	5	92.69	800	849 =	4	93.05	850	899 =	6	93.59
900	949 =	3	93.86	950	999 =	1	93.95	1000	1049 =	5	94.4
1050	1099 =	1	94.49	1100	1149 =	3	94.77	1150	1199 =	1	94.86
1200	1249 =	3	95.13	1250	1299 =	4	95.49	1300	1349 =	2	95.67
1350	1399 =	3	95.94	1400	149 =	1	96.03	1450	1499 =	1	96.12
1500	1549 =	2	96.3	1550	1599 =	3	96.57	1600	1649 =	0	96.57
1650	1699 =	0	96.57	1700	1749 =	0	96.57	1750	1499 =	3	96.84
1800	1849 =	4	97.2	1850	1899 =	0	97.2	1900	1949 =	0	97.2
1950	1999 =	0	97.2	2000	2499 =	5	97.65	2500	2999 =	5	98.1
3000	3499 =	2	98.29	3500	3999 =	1	98.38	4000	4499 =	1	98.47
4500	4999 =	2	98.65	5000	5499 =	0	98.65	5500	5999 =	2	98.83
6000	6499 =	0	98.83	6500	6999 =	3	99.1	7000	7499 =	1	99.19
7500	7999 =	0	99.19	**>=**	8000 =	9	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	6.499	11.891
<600	1.945	3.559
Tot Pct	90.25	
Tot No	1000	
600-4000 (1 mm)	1.386	2.535
Tot Pct	8.12	
Tot No	90	
4000 (1 mm) - 8000 (2mm)	0.63	1.152
Tot Pct	0.81	
Tot No	9	
> 8000 (2mm)	2.539	4.645
Tot Pct	0	
Tot No	9	



Summary of speciman WR1A.CHO on 02/15/2001
ASTM C-457 Procedure A

Length = 83.39887 | Percent Air = 5.832 | Average Air Void = 0.00417
Void/Paste Ratio = 0.119 | Percent Paste = 48.97 | Paste/Void Ratio = 8.4
Standard Dev of Air Void Sizes = 0.01865 | Voids Per Inch = 13.99
Spacing Factor = 0.00611 | Specific Surface = 959.8

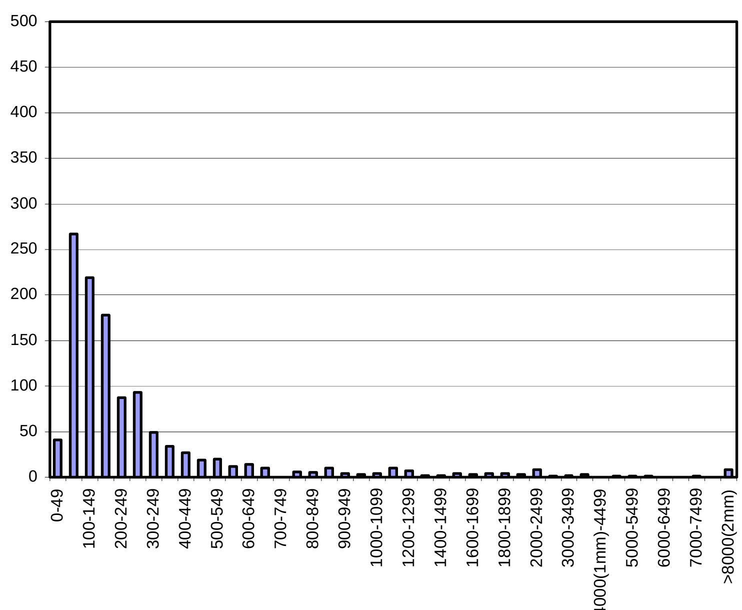
Specification Range: 0.004 - 0.008 | **Specification Range: 600 - 1100**

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	41	3.51	50	99 =	267	26.39	100	149 =	219	45.16
150	199 =	178	60.41	200	249 =	87	67.87	250	299 =	93	75.84
300	349 =	49	80.03	350	399 =	34	82.95	400	449 =	27	85.26
450	499 =	19	86.89	500	549 =	20	88.6	550	599 =	12	89.63
600	649 =	14	90.83	650	699 =	10	91.69	700	749 =	0	91.69
750	799 =	6	92.2	800	849 =	5	92.63	850	899 =	10	93.49
900	949 =	4	93.83	950	999 =	3	94.09	1000	1049 =	1	94.17
1050	1099 =	3	94.43	1100	1149 =	5	94.86	1150	1199 =	5	95.29
1200	1249 =	6	95.8	1250	1299 =	1	95.89	1300	1349 =	2	96.06
1350	1399 =	0	96.06	1400	149 =	1	96.14	1450	1499 =	1	96.23
1500	1549 =	1	96.32	1550	1599 =	3	96.57	1600	1649 =	1	96.66
1650	1699 =	2	96.83	1700	1749 =	2	97	1750	1499 =	2	97.17
1800	1849 =	2	97.34	1850	1899 =	2	97.51	1900	1949 =	1	97.6
1950	1999 =	2	97.77	2000	2499 =	8	98.46	2500	2999 =	1	98.54
3000	3499 =	2	98.71	3500	3999 =	3	98.97	4000	4499 =	0	98.97
4500	4999 =	1	99.06	5000	5499 =	1	99.14	5500	5999 =	1	99.23
6000	6499 =	0	99.23	6500	6999 =	0	99.23	7000	7499 =	1	99.31
7500	7999 =	0	99.31	**>=**	8000 =	8	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	5.832	11.909
<600	2.283	4.662
Tot Pct	89.63	
Tot No	1046	
600-4000 (1 mm)	1.672	3.414
Tot Pct	9.34	
Tot No	109	
4000 (1 mm) - 8000 (2mm)	0.274	0.56
Tot Pct	0.34	
Tot No	4	
> 8000 (2mm)	1.602	3.272
Tot Pct	0	
Tot No	8	



Summary of speciman WR1B.CHO on 02/15/2001
ASTM C-457 Procedure A

Length = 83.72443 | Percent Air = 6.724 | Average Air Void = 0.0042

Void/Paste Ratio = 0.147 | Percent Paste = 45.77 | Paste/Void Ratio = 6.81

Standard Dev of Air Void Sizes = 0.0143 | Voids Per Inch = 16.03

Spacing Factor = 0.00559 | Specific Surface = 953.48

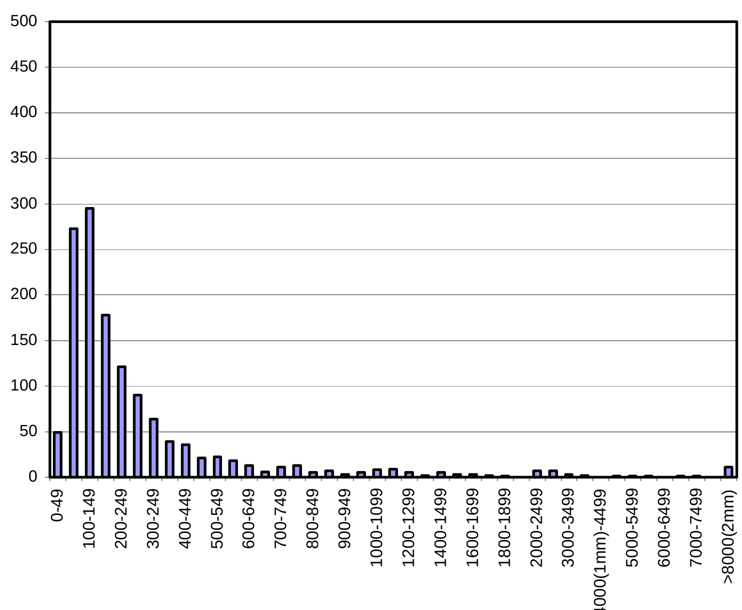
Specification Range: 0.004 - 0.008 | **Specification Range: 600 - 1100**

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	49	3.65	50	99 =	273	23.99	100	149 =	295	45.98
150	199 =	178	59.24	200	249 =	121	68.26	250	299 =	90	74.96
300	349 =	64	79.73	350	399 =	39	82.64	400	449 =	36	85.32
450	499 =	21	86.89	500	549 =	22	88.52	550	599 =	18	89.87
600	649 =	13	90.83	650	699 =	6	91.28	700	749 =	11	92.1
750	799 =	13	93.07	800	849 =	5	93.44	850	899 =	7	93.96
900	949 =	3	94.19	950	999 =	5	94.56	1000	1049 =	3	94.78
1050	1099 =	5	95.16	1100	1149 =	4	95.45	1150	1199 =	5	95.83
1200	1249 =	1	95.9	1250	1299 =	4	96.2	1300	1349 =	0	96.2
1350	1399 =	2	96.35	1400	149 =	2	96.5	1450	1499 =	3	96.72
1500	1549 =	2	96.87	1550	1599 =	1	96.94	1600	1649 =	2	97.09
1650	1699 =	1	97.17	1700	1749 =	2	97.32	1750	1499 =	0	97.32
1800	1849 =	0	97.32	1850	1899 =	1	97.39	1900	1949 =	0	97.39
1950	1999 =	0	97.39	2000	2499 =	7	97.91	2500	2999 =	7	98.44
3000	3499 =	3	98.66	3500	3999 =	2	98.81	4000	4499 =	0	98.81
4500	4999 =	1	98.88	5000	5499 =	1	98.96	5500	5999 =	1	99.03
6000	6499 =	0	99.03	6500	6999 =	1	99.11	7000	7499 =	1	99.18
7500	7999 =	0	99.18	**>=**	8000 =	11	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	6.724	14.692
<600	2.666	5.825
Tot Pct	89.87	
Tot No	1206	
600-4000 (1 mm)	1.779	3.887
Tot Pct	8.94	
Tot No	120	
4000 (1 mm) - 8000 (2mm)	0.356	0.778
Tot Pct	0.37	
Tot No	5	
> 8000 (2mm)	1.923	4.202
Tot Pct	0	
Tot No	11	



Summary of speciman WR2A.CHO on 02/15/2001
ASTM C-457 Procedure A

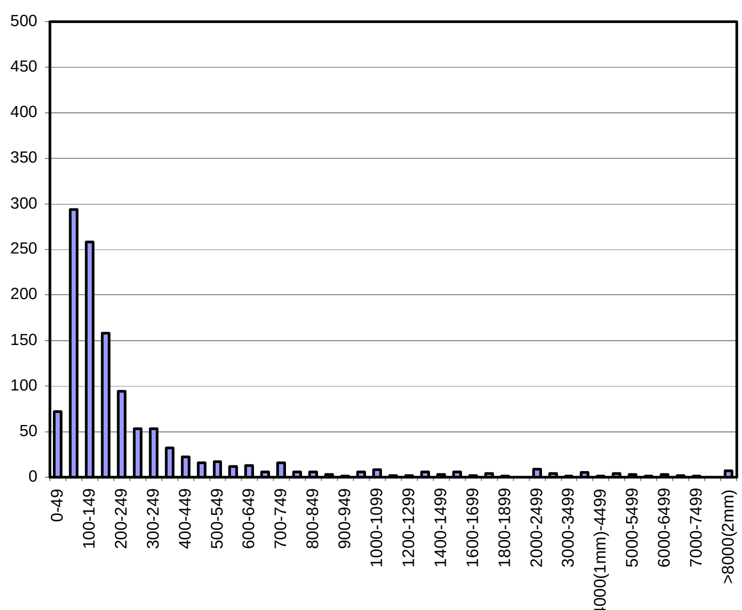
Length =	83.26141	Percent Air =	6.382	Average Air Void =	0.00438
Void/Paste Ratio =	0.128	Percent Paste =	49.86	Paste/Void Ratio =	7.81
Standard Dev of Air Void Sizes =	0.01753			Voids Per Inch =	14.57
Spacing Factor =	0.00622			Specific Surface =	913.14
Specification Range: 0.004 - 0.008				**Specification Range: 600 - 1100**	

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	72	5.94	50	99 =	294	30.17	100	149 =	258	51.44
150	199 =	158	64.47	200	249 =	94	72.22	250	299 =	53	76.59
300	349 =	53	80.96	350	399 =	32	83.59	400	449 =	22	85.41
450	499 =	16	86.73	500	549 =	17	88.13	550	599 =	12	89.12
600	649 =	13	90.19	650	699 =	6	90.68	700	749 =	16	92
750	799 =	6	92.5	800	849 =	6	92.99	850	899 =	3	93.24
900	949 =	1	93.32	950	999 =	6	93.82	1000	1049 =	4	94.15
1050	1099 =	4	94.48	1100	1149 =	1	94.56	1150	1199 =	1	94.64
1200	1249 =	1	94.72	1250	1299 =	1	94.81	1300	1349 =	5	95.22
1350	1399 =	1	95.3	1400	149 =	2	95.47	1450	1499 =	1	95.55
1500	1549 =	4	95.88	1550	1599 =	2	96.04	1600	1649 =	1	96.13
1650	1699 =	1	96.21	1700	1749 =	1	96.29	1750	1499 =	3	96.54
1800	1849 =	0	96.54	1850	1899 =	1	96.62	1900	1949 =	0	96.62
1950	1999 =	0	96.62	2000	2499 =	9	97.36	2500	2999 =	4	97.69
3000	3499 =	1	97.77	3500	3999 =	5	98.19	4000	4499 =	1	98.27
4500	4999 =	4	98.6	5000	5499 =	3	98.85	5500	5999 =	1	98.93
6000	6499 =	3	99.18	6500	6999 =	2	99.34	7000	7499 =	1	99.42
7500	7999 =	0	99.42	**>=**	8000 =	7	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	6.382	12.799
<600	2.179	4.371
Tot Pct	89.12	
Tot No	1081	
600-4000 (1 mm)	1.71	3.431
Tot Pct	9.07	
Tot No	110	
4000 (1 mm) - 8000 (2mm)	1.01	2.025
Tot Pct	1.24	
Tot No	15	
> 8000 (2mm)	1.482	2.972
Tot Pct	0	
Tot No	7	



Summary of speciman WR2B.CHO on 02/15/2001
ASTM C-457 Procedure A

Length = 84.18387	Percent Air = 7.605	Average Air Void = 0.00381	
Void/Paste Ratio = 0.154	Percent Paste = 49.24	Paste/Void Ratio = 6.47	
Standard Dev of Air Void Sizes = 0.01704		Voids Per Inch = 19.96	
Spacing Factor = 0.00497		Specific Surface = 1049.63	
Specification Range: 0.004 - 0.008		**Specification Range: 600 - 1100**	

Frequency Distribution of Air Voids (in Distance Pulse Counts)

Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.	Lower	Upper	No.	Pct.
0	49 =	60	3.57	50	99 =	381	26.25	100	149 =	371	48.33
150	199 =	209	60.77	200	249 =	148	69.58	250	299 =	104	75.77
300	349 =	81	80.6	350	399 =	57	83.99	400	449 =	48	86.85
450	499 =	36	88.99	500	549 =	20	90.18	550	599 =	14	91.01
600	649 =	12	91.73	650	699 =	13	92.5	700	749 =	14	93.33
750	799 =	7	93.75	800	849 =	3	93.93	850	899 =	8	94.4
900	949 =	9	94.94	950	999 =	2	95.06	1000	1049 =	2	95.18
1050	1099 =	4	95.42	1100	1149 =	7	95.83	1150	1199 =	2	95.95
1200	1249 =	4	96.19	1250	1299 =	2	96.31	1300	1349 =	5	96.61
1350	1399 =	1	96.67	1400	149 =	4	96.9	1450	1499 =	2	97.02
1500	1549 =	0	97.02	1550	1599 =	1	97.08	1600	1649 =	2	97.2
1650	1699 =	3	97.38	1700	1749 =	4	97.62	1750	1499 =	1	97.68
1800	1849 =	0	97.68	1850	1899 =	0	97.68	1900	1949 =	1	97.74
1950	1999 =	1	97.8	2000	2499 =	9	98.33	2500	2999 =	4	98.57
3000	3499 =	7	98.99	3500	3999 =	2	99.11	4000	4499 =	0	99.11
4500	4999 =	2	99.23	5000	5499 =	1	99.29	5500	5999 =	0	99.29
6000	6499 =	2	99.4	6500	6999 =	0	99.4	7000	7499 =	1	99.46
7500	7999 =	2	99.58	**>=**	8000 =	7	100				

Percent Air Summary by Size

Size	Concrete	Mortar
Total	7.605	15.446
<600	3.301	6.705
Tot Pct	91.01	
Tot No	1529	
600-4000 (1 mm)	2.076	4.217
Tot Pct	8.1	
Tot No	136	
4000 (1 mm) - 8000 (2mm)	0.597	1.212
Tot Pct	0.48	
Tot No	8	
> 8000 (2mm)	1.631	3.312
Tot Pct	0	
Tot No	7